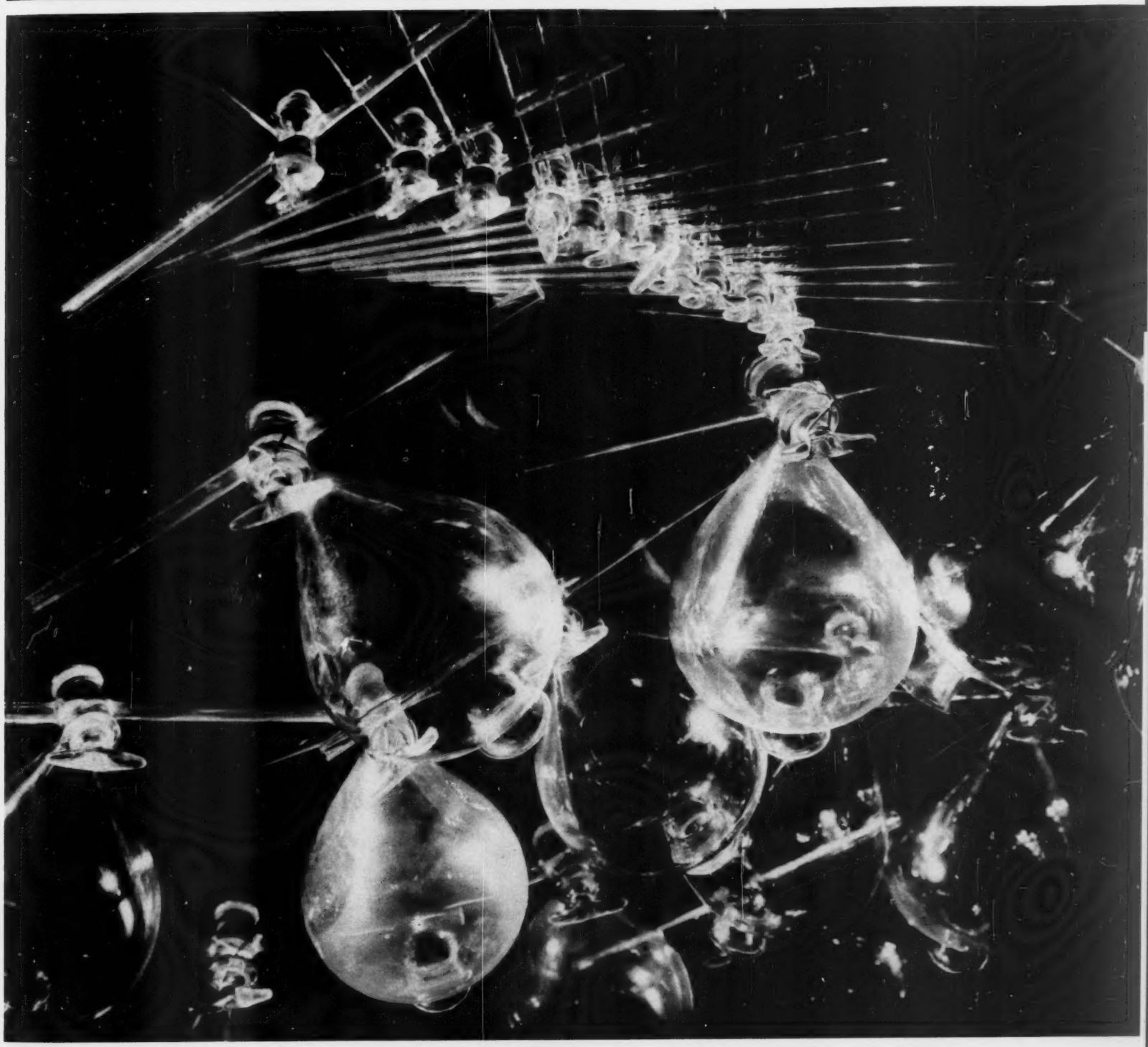
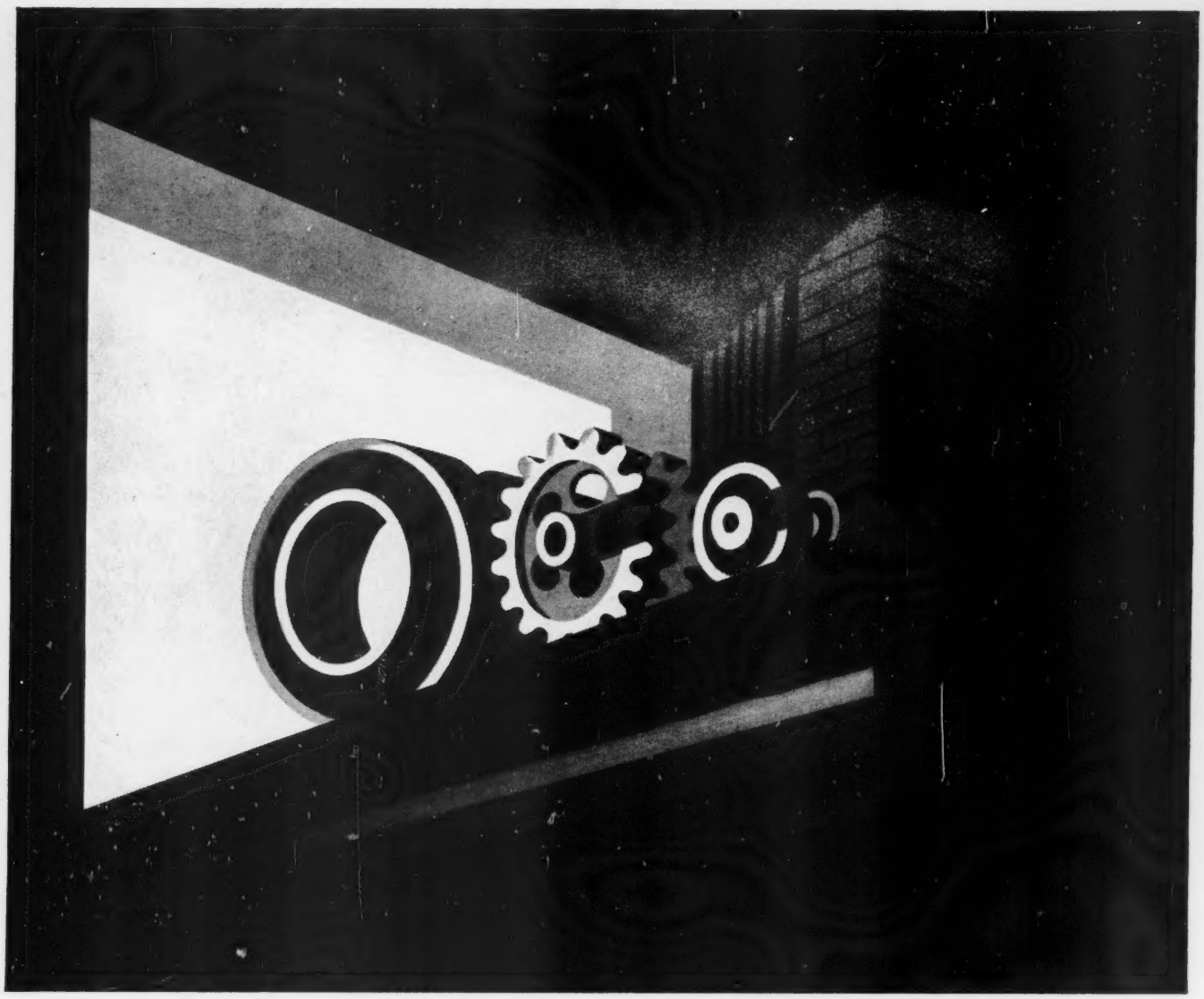
TECH ENGINEERING NEWS

Bureau of Standards
JAN 10 1939



NOVEMBER • 1938

Vol 19, no 6.



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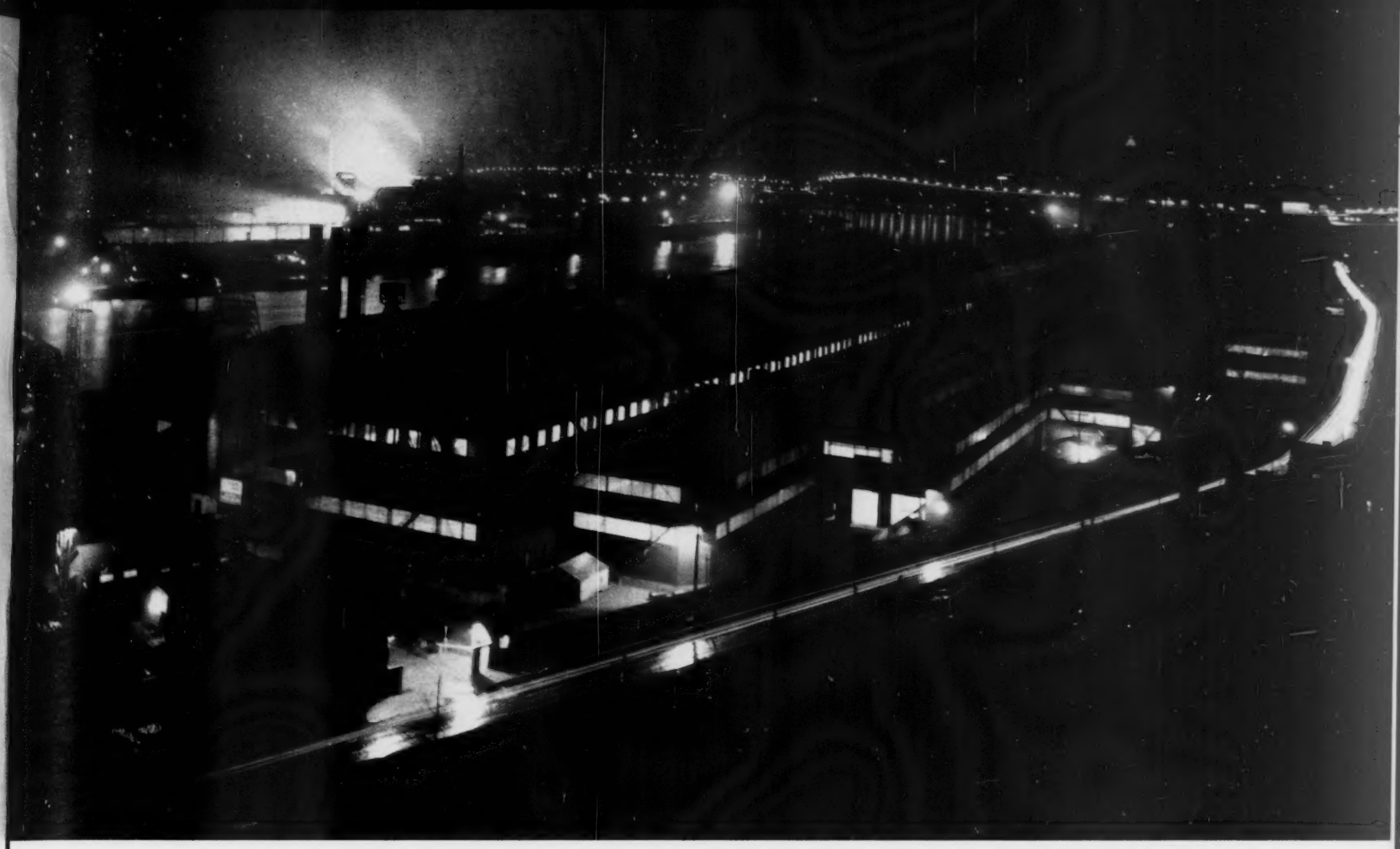

Jones & Laughlin Steel Corporation

OUR AUTHORS

C. S. McDOWELL, retired captain United States Navy, and supervising engineer of the Mt. Palomar project, has been on this job since its beginning some three years ago. A specialist in naval engineering and research problems, he was "lent" by the United States Navy at the request of the California Institute of Technology Observatory Council. Since that time he has resigned from his Naval work and is devoting full time to supervising construction of the telescope.

JOHN W. M. BUNKER writes this month's article on Biological Engineering. Dr. Bunker joined the Institute staff in 1921. He graduated with honors from Brown University in 1909, at which place he received his Master's degree and his Doctorate in Bacteriology in the two years following. He has done extensive work in industry in the field of biology, and since coming to the Institute has written numerous scientific papers on bacteriology, sanitation, biophysics, and vitamins.

SIR RAYMOND UNWIN, the noted British architect, is one of the foremost authorities on housing and city planning in the world. Municipalities in England which he has planned include New Earswick, York, the First Garden City of Letchworth, and the Hampstead Garden Suburb. From 1929 to 1933 he was Chief Adviser to the Greater London Regional Town Planning Committee. The Roosevelt administration, too, has consulted him in connection with the present housing program. He is an outstanding member of the Royal Institute of British Architects, serving as president from 1931 to 1933.

In 1934 Sir Raymond paid a visit to Canada and the United States, during which time he visited architectural societies, lectured, and inspected the housing and city planning situation. In an account of his trip in the Journal of the R. I. B. A., he makes an interesting comment on the speculative boom and slump in this country. He ascribes the severity of our depression to the fact that we consider annual income derivable from property as secondary in importance to the possibility of the property's increasing in value. This typically American viewpoint, he says, increases speculation and makes a following depression doubly severe.

Sir Raymond is neither a modernist nor a traditionalist, but he advises both schools of thought to consider the other carefully. His theory in planned group housing is that the individual building must conform with the group to arrive at a harmonious whole.

ARCHIBALD WILLIAMS, assistant professor of production management in the Department of Business and Engineering Administration, is well qualified to write on the technique of Time-Motion analysis. Since his graduation from the Institute in 1923 he has had wide experience in business and engineering, and particularly in the increasingly important field of Motion Study and Work Simplification. He has been associated, in various capacities, with the Hood Rubber Company and the Raytheon Production Corporation. Most of his work has been closely related to production and operating personnel. In his work on Time-Motion he has made extensive use of the motion picture camera to record inefficiencies in production.

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OUR COVER THIS MONTH

The cover this month is from a photograph composed at the Merck Research Laboratories

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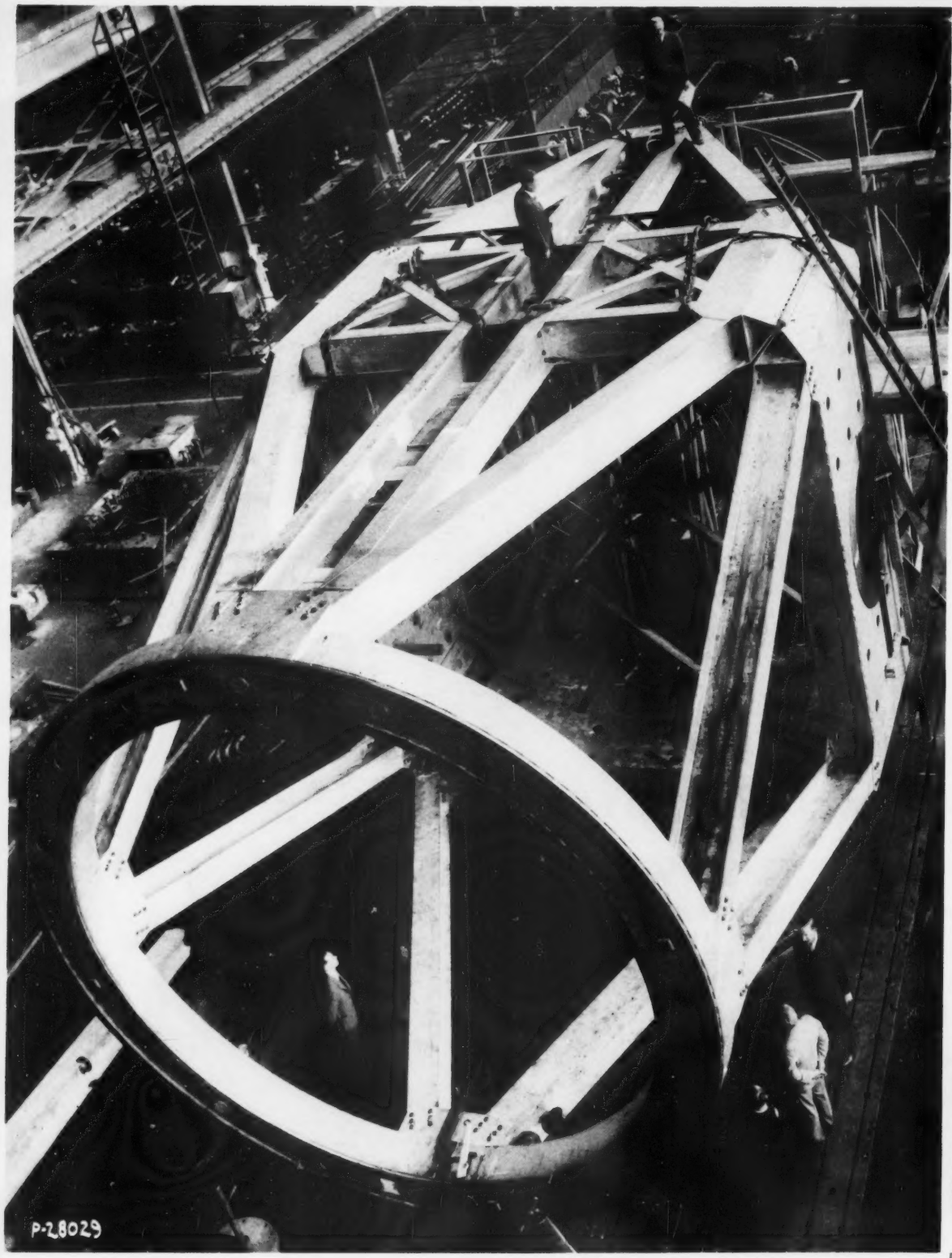
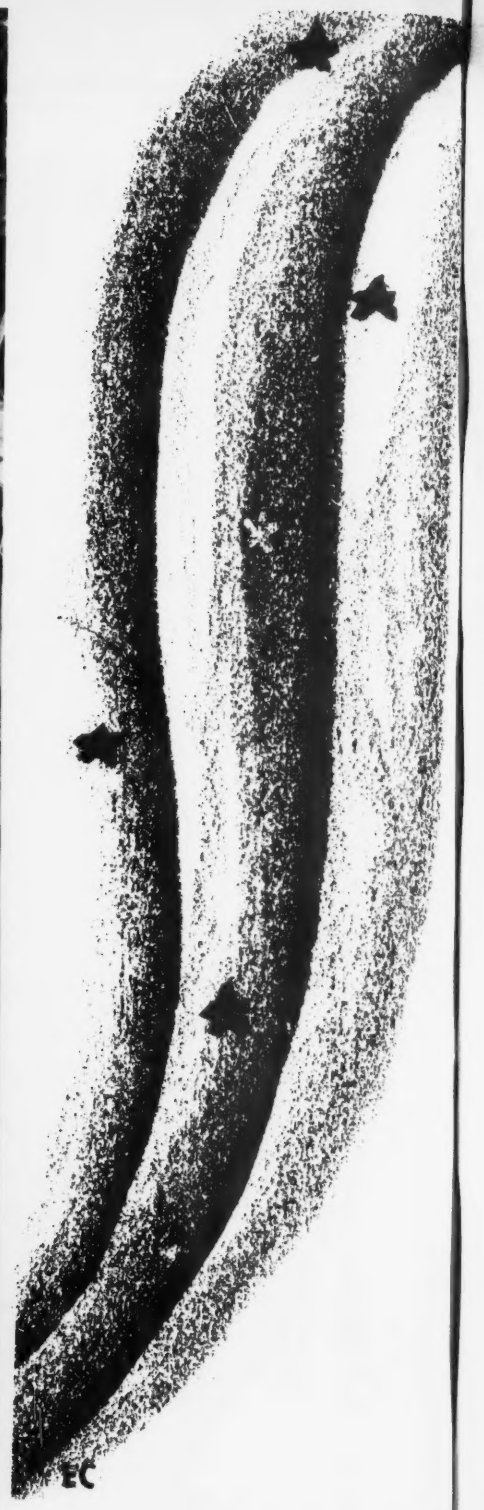




Courtesy Westinghouse

STARS·TO·CYCLOPS

★ CONSTRUCTING MT. PALOMAR'S 200" TELESCOPE ★

C. S. McDOWELL
Captain United States Navy

AS one stands today at the observatory site on Palomar Mountain there unrolls a vast, rugged, beautiful country — lesser peaks blanketed with tall, stately pines and oaks, gorges sharply threading their way between precipitous hills. On the gently rolling summit of this mountain, men are at work getting the observatory dome ready to receive the yoke and tube for the 200-inch mirror — and the mirror itself. The task is nearly completed.

We, who have been in charge of construction, have been fortunate in receiving whole-hearted co-operation from a vast number of engineers and scientists scattered throughout the nation. Such assistance was very necessary in order that we might make the telescope and the observatory the best that science and engineering of today can produce. Taking the astronomical specifications which represent what the astronomers would like to have, and applying what has been developed in kindred fields, we find that we have promise of an instrument even better than the astronomers' fondest dreams. It is hoped that, 50 years hence, this instrument will still be considered modern, and that it will, to a certain extent, be an achievement of which all scientists and engineers of this decade, 1930–40, may well be proud.

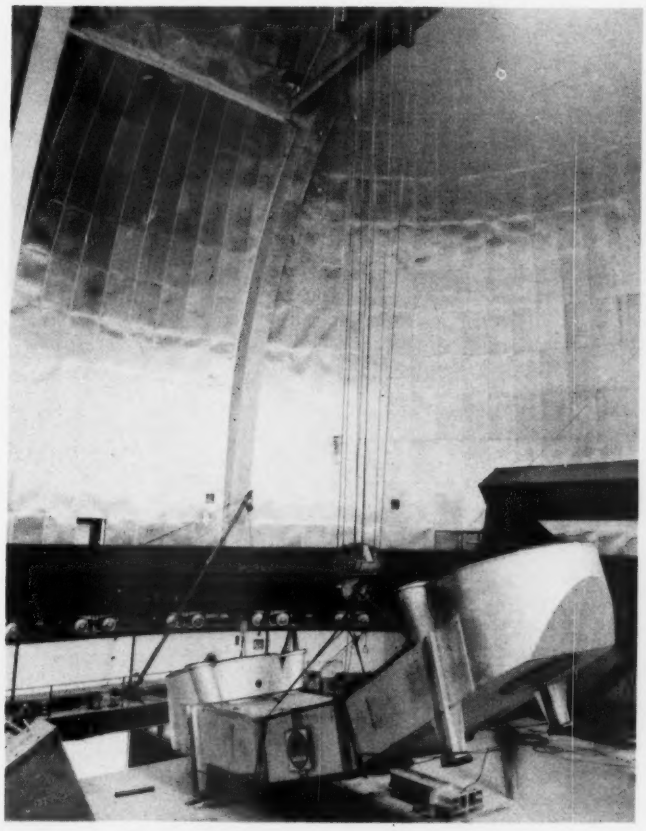
When the 200-inch telescope is finally completed and it begins its task of exploration, it will doubtless reveal new facts about which, at present, we have no clue. Beside these unknowns, however, at least three branches of astronomy will have immediately available new knowledge about the universe in which we live. First, the astronomical horizon will be pushed out. The volume of space whose contents can be studied will be approximately eight time larger than at present. Second, due to the great light-gathering power of this instrument, it will be possible to make large-scale spectra of the brighter stars and increase our knowledge of their atmospheres. Third, much new material will become available about our neighbors in our own solar system, namely, the planets and asteroids.

One of the first undertakings, after obtaining necessary funds for this project, was the investigation of various locations to determine the site for the new observatory. About five years were spent in the study of possible sites throughout southern California and Arizona, with parties under the direction of Dr. J. A. Anderson, in the field, taking data to determine the average "seeing" obtained at different places, as well as tabulating meteorological data. "Seeing" to an astronomer is a most important factor. If the "seeing" is good, the image of a star is of small diameter and free from local movement, but if there is turbulence in the upper air, the "seeing" becomes bad and the image may become so large and so variable in its position that no satisfactory observation can be made.

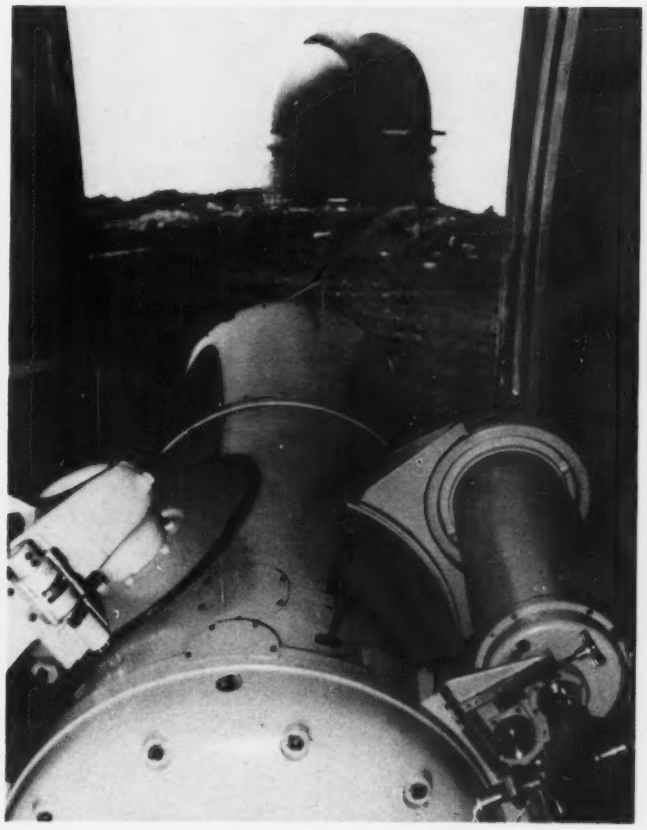
Palomar Mountain, San Diego County, California was finally selected, for it could be easily reached and had available a supply of water for construction purposes and also for use at the observatory when complete and in operation. Moreover, the County had volunteered to construct a new high gear road to the site, which would be necessary in order to transport the tube and mounting, and the various other heavy parts which would be needed for the dome itself. In order to have a suitable location which would be satisfactory now, as well as in the future, the site had to be remote from any probable development of urban population, and free from skylights from such settlements.

Today a concrete and steel dome, 137 feet in

South cross piece on observing floor
Note steel base frame for telescope mounting



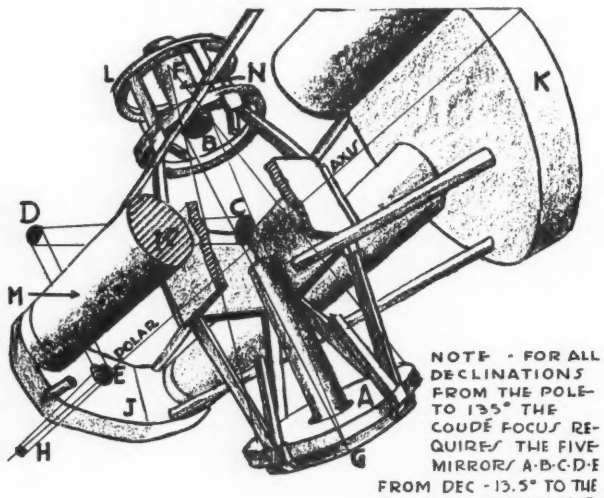
View of the dome through shutters
of the 18-inch Schmidt Auxiliary Telescope



diameter and height, stands on the mountain, ready to receive the 200-inch telescope. The telescope tube and its mounting are nearing completion at the South Philadelphia Works of the Westinghouse Electric and Manufacturing Company, and will be shipped to Palomar Mountain for installation this fall.

The lower, or stationary part of the dome, has a steel framework to take the bearing loads and has a double outer wall of reinforced concrete, 30 feet high. Between the outer and inner walls there is a 12-inch air space which permits the escape of heated air through connections to a similar air space in the upper dome, where it is vented at the top. This space helps to eliminate heat from the lower spaces of the dome. Also, the inner wall is insulated. These two precautions, aimed at the reduction of the ill optical effects of small temperature differences on the telescope mirrors and on the path traversed by the light, will keep the space below the observing floor near the outside night air temperature. Early each night the air in the lower dome will be pumped out and this space will be filled with cool night air, so that there will be no gradual accumulation of heat in the lower portions of the dome.

On the lower floor there is a workshop, consisting of dark rooms, physical and chemical laboratories, a library and lounge, lunch room, astronomers' offices, air conditioning machinery, and a storage space for material and equipment, where the astronomers will develop plates, carry on their studies, and "loaf". A passenger elevator is provided between the ground floor and mezzanine and operating floors and the balcony just above the operating floor. From the balcony landing a short stair leads to the prime focus platform extending toward the prime focus observing station at the top of the telescope tube. Thus the facilities on this lower floor are easily and readily accessible to the astronomers from all observing stations.



NOTE - FOR ALL DECLINATIONS FROM THE POLE TO 135° THE COUDÉ FOCUS REQUIRES THE FIVE MIRRORS A·B·C·D·E FROM DEC - 13.5° TO THE SOUTHERN HORIZON, D & E ARE UNNECESSARY.

A · 200 INCH MIRROR
B · 41", 37", & 32" CONVEX
C · COUDÉ MIRROR
D · 23" GANTRY MIRROR
E · 19" MIRROR
F · PRIME FOCUS f 3.3
G · CASSEGRAIN FOCUS f 16
H · COUDÉ FOCUS f30
I · CASS. FOCUS (COUDÉ)
J · YOKE
K · HORSESHOE (SPLIT RING)
L · REVOLVING CAGE
M · SPECTOGRAPH CHAMBER
N · CORRECTING LENSES

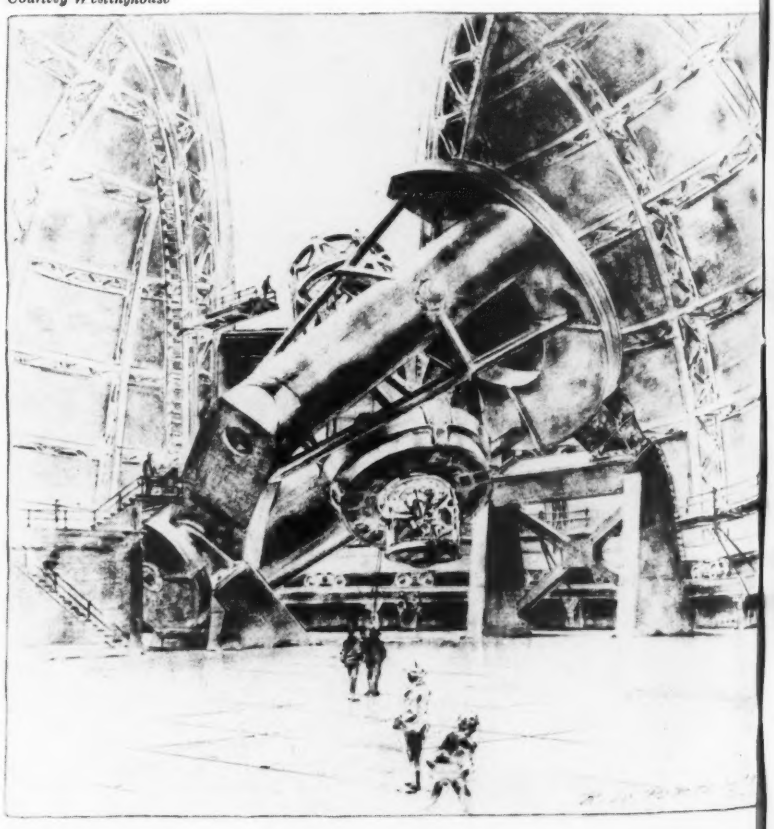
There is a structural steel base-frame which supports the telescope mounting. This base-frame has its own foundations separate from those of the dome. Tests have shown that there is a very low "coefficient of coupling" between this base-frame and the dome, practically preventing any vibrations, which may be set up in the dome, from reaching the telescope. The base-frame supports, on its upper part, four pedestals which project through the upper floor and carry the cross girders, which in turn provide supports for the north and south — or polar axis — bearings. Midway between the lower and observing floors is a mezzanine floor extending over half the dome. This provides space for the main electrical distribution and control panels, motor-generator sets, time standards, storage batteries, and so on. It will also provide storage space for spectrographs and other equipment.

The upper or rotating part of the dome is a completely welded steel structure covered with 3/8-inch butt-welded steel plates. These plates form the outer shell of the dome. This dome is supported through springs on 32 four-wheel trucks which roll on an accurately ground circular track. Directly under the arch is a 60-ton crane, installed to facilitate the assembly of the telescope. An adjustable wind screen is arranged in the 30-foot-wide shutter opening to avoid any undesirable air currents when the telescope is pointing to the region of the skies near the zenith.

In order to keep the day temperature inside the dome close to the prevailing night temperature, the rotating dome is lined on the inner surface with panels of aluminum foil insulation. These panels are inside the ribs of the dome and provide a four-foot air space, with vents at the top of the dome. The panels are faced with aluminum on their inner side, thus providing a smooth interior surface of aluminum for the dome. The essential mechanical parts of every telescope are the tube carrying the entire optical system, the declination axis carrying the tube, and the mounting supporting the tube, by means of this axis. The 200-inch telescope is of the commonly employed equatorial type. This type of telescope permits observing at virtually any point of the heavens, by rotating the tube of the tele-

(*Continued on page 146*)

Courtesy Westinghouse



Tools pre-positioned

Releasing both hands for productive effort

Reaching and handling minimized

All photographs courtesy Westinghouse

Time and Motion Study

PROFESSOR A. WILLIAMS

By the use of relatively simple techniques of scientific analysis (motion study), it is possible to weed out and eliminate many of the waste and non-productive motions, as well as operations, performed by the average worker. By substituting productive and useful motions for these waste ones, the worker is enabled to produce more units of work with the same expenditure of effort as before . . . it is extremely important that this concept and understanding of what *Work Simplification really is be clearly and firmly established in the minds of management, the supervisory organization, and employees alike. Work Simplification may thus be clearly distinguished, in the workers' minds, from the so-called "speed-up" or "stretchout," which is also designed to increase employee productivity, but which does so only at the expense of the worker who has to work harder or faster to attain the same level of earnings as before.*

THE fundamentals and techniques of motion study were established during the first quarter of the century as the result of the pioneering efforts of Frank B. Gilbreth. Although many students of management may remember that Frederick W. Taylor had outlined job analysis and methods improvement as an essential division of his celebrated technique of Scientific Management in the early eighties, it remained for Gilbreth, many years later, to develop and perfect the necessary tools and techniques which crystallized this idea into a practical possibility.

Gilbreth dedicated the greater part of his life to the fascinating study of how people do work, and among other contributions he coined the expression "The One Best Way" to identify the method involving the most effective utilization of physical motions, equipment and materials. Motion study, therefore, can be defined, simply and understandably, as the *means* for discovering "The One Best Way" of performing any given task; while Work Simplification is defined as the *objective.*

Motion study, as developed by Mr. and Mrs. Gilbreth, has been effectively employed over the years by many industries to establish the most efficient way, or the *how* of doing work. By the use of relatively simple techniques of scientific analysis, it is possible to weed out and eliminate many of the waste and non-productive motions, as well as operations, performed by the average worker. By substituting productive and useful motions for these waste ones, the worker is enabled to produce more units of work with the same total expenditure of effort as before.

The actual tools and techniques used in analyzing and simplifying any given operation or process remain essentially simple to learn and to apply. The basic procedure in the application of Work Simplification is that all work, considered as a process or an individual operation, is broken down into elements as small as possible, or as small as the analysis warrants. These elements are then studied and analyzed from the standpoint of the following four possibilities: (1) Elimination; (2) Combination; (3) Change of Sequence, and (4) Simplification.

The degree of refinement to which the analysis is carried is dependent upon the type and conditions of the job. The use of process charts for the purpose of accurately recording information and graphically presenting it is particularly helpful in detecting the presence of any waste or "bottle-necks" in a given process. The process chart is generally used in the analysis of entire processes or over-all studies of the major elements of an operation. The three types of process charts most frequently used by the analyst are: the *flow* chart; the *man-machine* chart; and the *operator* chart.

The *flow* chart is made by following the part or product through all the stages of processing, until it leaves the plant. Such a chart subdivides the various steps of manufacture into operations, transportation,

storage and inspection. These elements of work are denoted by symbols which assist the analyst in visualizing the process. Whenever a move or handling occurs, the distance traveled is shown; and wherever the element of time may be of subsequent importance it is also indicated. To aid further in visualizing the flow of work, flow diagrams, which are floor plan layouts of the buildings and equipment, are used. The use of templates (patterns) of the equipment and parts storages, benches, etc., greatly facilitates the problem of consi*d*ering the various possibilities in planning the new l ayout.

The *man-machine* chart indicates the elements of work performed by the operator as compared to the operating and idle time of the machine. The elements of operator-motion are observed, measured, timed and recorded in the sequence in which they occur. For means of comparison, the time of machine operation is likewise recorded in the relative position in which it occurs in the cycle sequence. Such a chart serves to indicate the degree of machine utilization which is being obtained. It also emphasizes the *human* element which is necessary to the proper manipulation and control of the machine.

The *operator* chart shows in considerable detail the left and right hand motions of the operator while performing an operation. The operations and movements of each hand are recorded in the order in which they occur. Because of the rapidity and frequency of these movements, it is sometimes desirable to group all the movements required for any given element of the cycle. In general no attempt is made to time the individual movements, although over-all cycle times are frequently valuable for comparing methods. Such charts are extremely helpful in instructing the workers in the method, or serving as permanent records of the method for future reference. Usually this type of chart includes a sketch of the workplace, indicating the layout of materials and equipment.

The *micro-motion* chart is a further refinement of the left and right hand *operator* chart. It is made by filming the operation, including in the picture a high speed clock, or using a constant speed camera and special projector. The fundamental elements of motion are then recorded and measured to very small units of time, thus permitting a degree of refinement in analyzing the operation which would be impossible through the use of the *operator* chart.

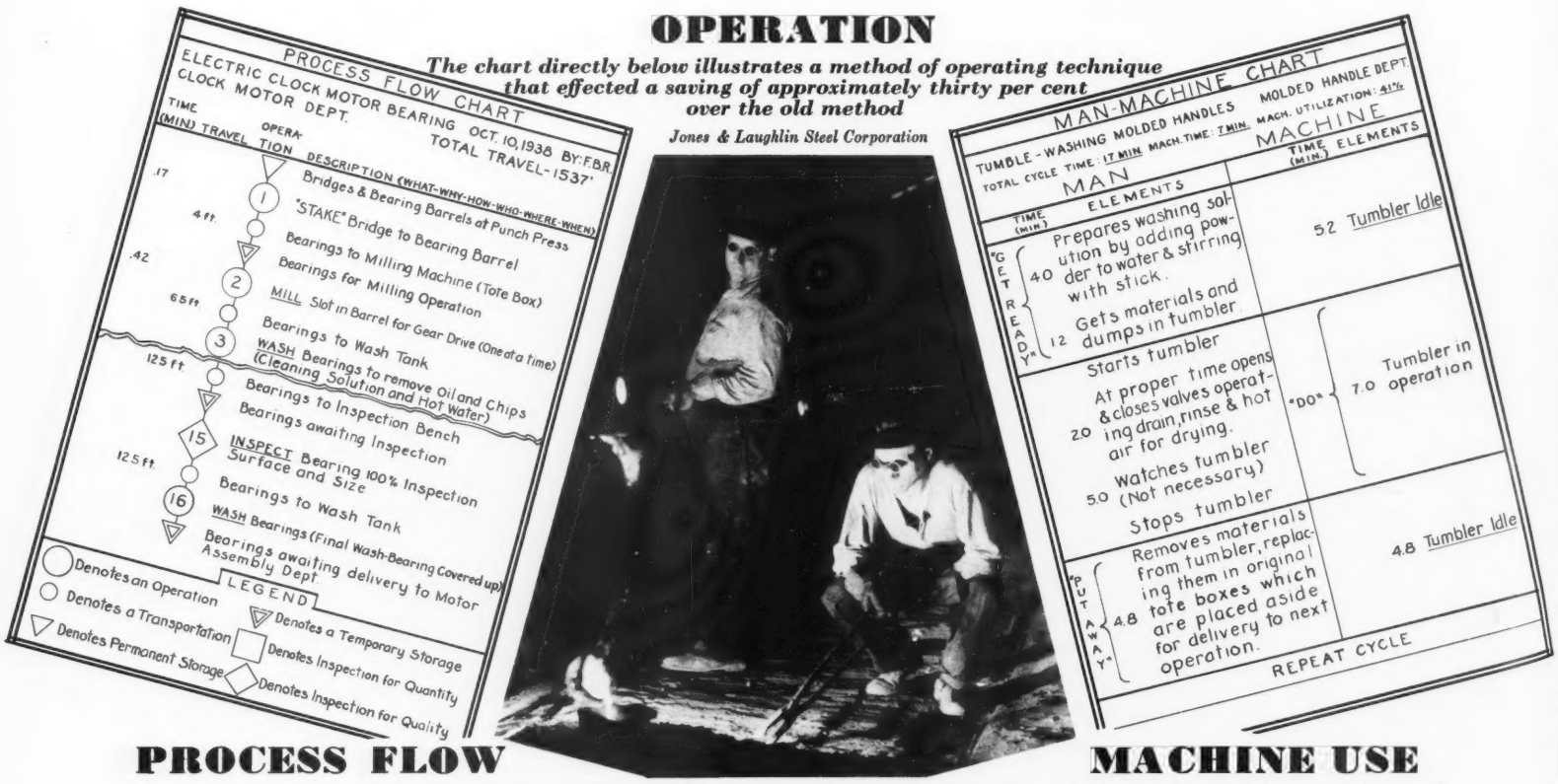
Despite the spotlight of attention which has been focused on them, the worker and the workplace still remain fruitful sources of improvement and cost reduction. The use of only one hand working at a time, the other remaining idle or causing a delay, and the habit of using one hand

(*Continued on page 142*)

OPERATION

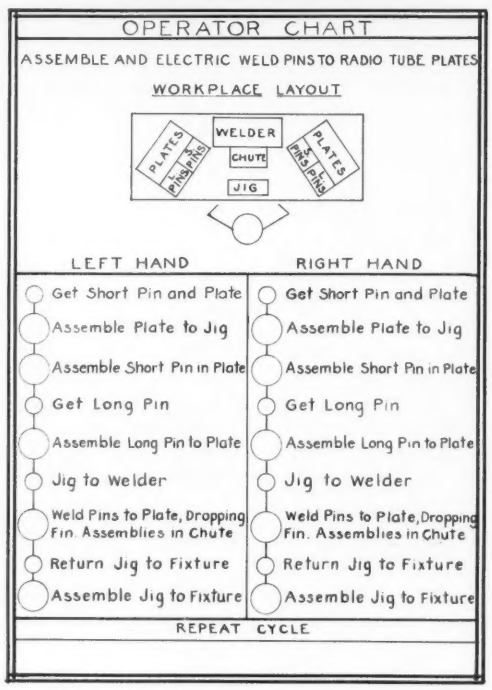
The chart directly below illustrates a method of operating technique that effected a saving of approximately thirty per cent over the old method

Jones & Laughlin Steel Corporation



PROCESS FLOW

In the case of the above series of operations it was found by a careful study of the chart that the number of operations and travel distances could be appreciably reduced with resultant economies of time and cost.



MACHINE USE

By improving the "get-ready" and "put-away" elements of the above operation and also by performing it during the "do" part of the cycle, it was possible to increase greatly the utilization of the equipment.

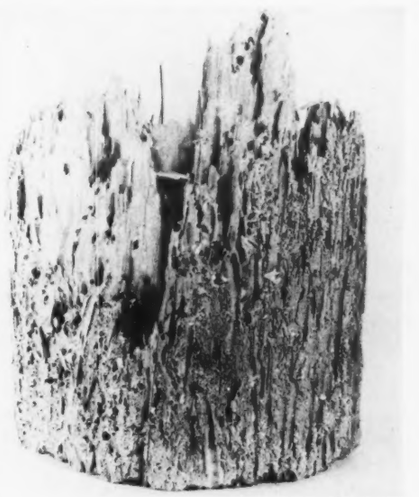
Biological Engineering

A NEW COURSE FOR THE MAN OF ABILITY, IMAGINATION, AND COURAGE

JOHN W. M. BUNKER

THE Institute buildings rest on a foundation of wooden piles, once living tree trunks, now submerged under ground water. As long as the level of the water does not become lowered these piles will continue to lend adequate structural support, but if the tops were to be exposed to the air in dry ground, they would rot. Such a failure would be due to the action of living microbes, bacteria and fungi, which can live and attack the wood only if they have air to breathe.

Wharves and water-front structures are also built upon piles, usually not completely submerged even at high tides, but in this case failure is likely to occur below even low water level. Here the failure in the wooden structure is due also to biological agencies, but in this case the attacking organisms are shipworms which bore into the wood and honeycomb the structure with their tunnels. In Boston Harbor within two years the cost of replacing piling ruined by teredos and other marine borers has been of the order of five million dollars.



All photographs courtesy W. F. Clapp Laboratories

Harbor pole ruined by shipworms and other marine biological agencies

It is a problem for the biologist and engineer to determine first, the cause of such failures, and second, how to circumvent or prevent the biological attacks. Thousands of test boards are located in harbors from Spitzbergen to Singapore for the study of the habits of these marine borers, and for the testing of preservatives against their depredations. The utilization of the scientific data obtained by such studies and their application in a systematic way constitutes one illustration of biological engineering.

Life upon this planet is dependent upon sunshine. Aside from the effects of solar energy upon climate, it is also true that without radiant energy we would have no food. By the well-known process of photosynthesis, green leaves combine radiant energy with the chemical elements: carbon, hydrogen and oxygen, in proper proportions and in a suitable configuration to constitute that type of food which we call carbohydrate, or more commonly sugar and starch. All the food of all plants and all animals, including man, is derived from this elementary carbohydrate. Radiant energy emitted from man-made sources such as arc lamps and the like can also be utilized by the chlorophyll of green plants for the synthesis of starch, and in various laboratories the study of the chemistry and the physics of starch production by this catalytic agent with the aid of radiant energy from controlled sources is receiving attention. There is no reason to suppose that eventually the biophysicist will not succeed in this problem of elementary food production independent of sunlight When that time comes the practical application of the scientific techniques which are proved to be successful must take place in the methodical, efficient manner of the engineer. This will be biological engineering.

When we are sick, we turn to the doctor. For the prevention of sickness of certain types the microbe hunters of the world have developed sanitary science to a high degree of efficiency. This has been the contribution of the public health specialist. Applications of knowledge concerning the cause and transmission of malaria and the sanitary engineering measures taken in the Canal Zone made possible the completion of the Panama Canal. This methodical application of the facts of biological science combined with the technique of the civil engineer for a definite benefit to human welfare was, in fact, if not at the time in name, an example of biological engineering. In the same category are classified the methods of large scale preservation of goods and the manner of their storage and handling to prevent spoilage. It seems highly probable that the selection of data from available agricultural science by the engineer and its application to the conservation of the border-line farm areas of our West would be a type of biological engineering of incalculable value to our country.

Man is engaged in warfare against the living parasites which contend with him for supremacy on the earth. Insect parasites which destroy crops; parasites like the termites which bore into his houses; microbes which cause diphtheria, typhoid fever, scarlet fever; molds and bacteria which cause spoilage of the food he has gathered; all are constantly busy and are working against the welfare of mankind. Biological science has already shown how to combat many of the communicable diseases and to preserve foods and structures to some extent against spoilage, but it has not yet succeeded in ascertaining how to control infantile paralysis or the common cold. Great financial loss is incurred constantly from food spoilage, fruit infestations, depredations of insects and rodents, by mildew of textiles, by termite invasion of buildings, and by wastage of vegetable and animal materials. Progress in the conservation of biological resources should come from precise analysis of problems and systematic applications of science with the careful planning which is characteristic of the engineer.

Living matter and non-living matter have in common a structure of matter, molecules and energetics

Testing Weber's Law for audibility sensation in the biological engineering laboratories at Massachusetts Institute of Technology

Physical laws which formulate the relations of matter or energy in the lifeless world also apply to these relations in the world of the living. Biological science is one category of facts, relations and laws concerning matter and energy, just as chemistry and physics are other categories of the same broad classifications. No boundaries can be drawn to delimit sharply the fields of science; each merges into the other; the names which man has attached to the centers of interest in each field are for convenience in description and reference, and do not represent individual factual entities.

The techniques of experimental physics and chemistry have been applied to the study of biology with success, and the greater precision of measurement and of description of biological phenomena made possible thereby are changing the character of biology from descriptive to analytical. It is only by repetition that tests of theory can establish truth, and true repetition can be effected only when reproducible precision of essential measurement characterizes the test. Chemical and physical measurements in biological investigation have supplied the precision necessary for experimental tests in experimental biology.

The human mechanism can be most intelligently directed for the maintenance of health and the avoidance of disease only after man learns how this mechanism operates. This brings in the fields of physiology and biological chemistry. The more complete his knowledge of energy transformations and other chemical reactions of life, the better can man expect to live.

Measuring body impedance

Biology is the name given to one subdivision of natural science and relates particularly to the facts concerning life and the products of living things. Originally a matter of observation, description, and classification, natural history described the scope of biology. Following the period of description and classification, there developed a period of inquiry into the nature of these forms, the changes which they were observed to undergo, and the accumulation of data concerning the analysis of life processes. Thus was developed a body of fact within the broad field of biology which has been designated as physiology. The great advance in physiology was achieved after realization that the functions of life are largely manifestations of chemical reactions. The utilization of expanding knowledge in the field of science designated as organic chemistry has resulted in great advances in our knowledge of the phenomena of life, and the accumulation of chemical data related to physiologic happenings has, in turn, been dignified with its own identifying title, biochemistry.

Recently one of our organic chemists, interested in the subject of peroxide formation in certain organic chemicals, devised a new type of peroxide of one of the higher alcohols. One of his biological colleagues, interested in the killing of bacteria, proved that the new synthetic peroxide is a potent bactericide. Another colleague afflicted with athlete's foot, which is a disease of the skin caused by a fungus, wondered if the new peroxide might not be useful in combating that ailment. Trial proved that the hope is substantiated by fact. The hydroperoxide of tertiary butyl alcohol is now being produced in large quantities and is being supplied to physicians who are finding for it new uses daily, not only in the original field of a specific for athlete's foot, but for treating pyorrhea, boils, and numerous skin infections. It has been used successfully in our own Homberg clinic.

It has long been known that the ultra-violet portion of sunlight when allowed to fall upon the skin of infants with weak bones will, if the diet of the infant be properly balanced, result in a marked strengthening of those bones. Working with experimental animals, usually white rats, in our own biological laboratories, we

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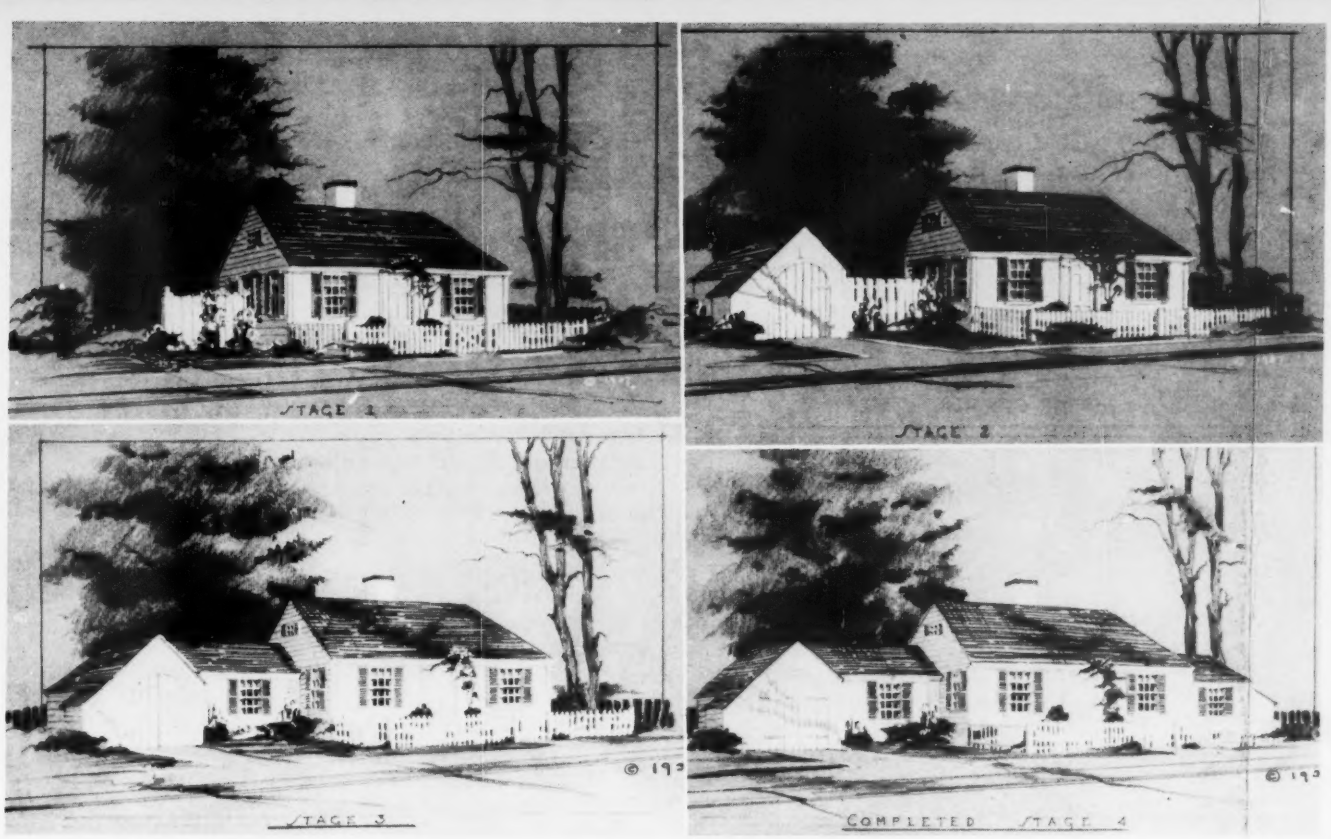


The "Add-Easy" properties of this house designed by Royal Barry Wills of Boston suggest, to some extent, the kind of standardization Sir Raymond contends is the solution to America's serious housing problem.

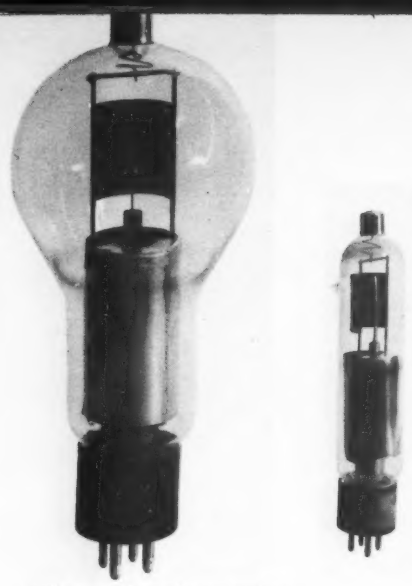
Crowding the Jerry-Builder

• METHODS OF LOWERING OUR EXCESSIVE HOME-BUILDING COSTS

SIR RAYMOND UNWIN

RECENTLY, while in the United States, I came on the not unfamiliar sight of the devotee of a system of prefabricated houses, laboriously erecting inferior dwellings; and offering them at a price sufficient to provide well-built permanent structures. The sight was familiar because similar attempts were made many times during the difficult days for housing in England just after the war, when prices were double or treble those prevailing before its outbreak, and when even an inferior alternative type of house at reasonable cost would have been welcomed. There is so much said about the prefabricated house as promising a solution for the housing problem in the United States of America that one wonders whether too much reliance is not being placed upon it, to the neglect of other more certain, if less spectacular ways of securing economy in building costs. An examination of the possibilities and limitations of prefabrication may therefore be a useful approach to the consideration of alternative methods for securing economy in the provision of low rent dwellings. The words low rent suggest a starting point; because for the low income groups low rent must be the aim; low cost, if it is secured by reducing the life of the building, is not enough; for the increased sum added to the rent to amortize a capital cost of the building, say in 25 years instead of 60, will outbalance a very considerable reduction in that capital cost. This was one of the main reasons why wooden structures proved unattractive in the English housing program, even though the cost of the wooden shell might be considerably less than the brick building. The increased amortization and insurance rates put up the rents more than the reduced costs could bring them down. For example, on the basis of a 3½ per cent rate of interest, the costs of a $4,000 dwelling with 60 years amortization would need to be reduced by one third, to $2,666, if the amortization period were to be reduced to 25 years without increase of rent. Such an economy is not easy to secure by any form of production. The often quoted but misleading analogy with the factory built motor car is probably responsible for much misapprehension as to the possible reduction in cost which might result from prefabrication of dwellings. If the items of cost be considered, the fact will soon appear that a large proportion of them could be little affected by the method of production. For example, the cost of the site of the roads giving access to the building, of all the services in the roads and the connections from them to the dwelling would remain, even if the dwelling could be carted to the site ready erected. Moreover, many of the parts of a house are already prefabricated in forms convenient for packing and transportation; doors, door frames, windows, baths, sinks, toilets, taps, and other fittings are already subject to mass production. True it would be possible to connect all the plumbing pipes to the taps and fittings in the factory, but to convey such a clumsy erection to the site would be more costly than any possible difference between the prefabrication cost and that of making the connections on the site

(*Continued on page 144*)



Ultra-violet photo tubes

GERM PROOF CURTAINS OF LIGHT

ULTRA-VIOLET radiations, known popularly as "black light," have long been applied to various medicinal techniques. For example, portable ultra-violet lamps are in frequent use today, both in the home and in the office. Ultra-violet rays cure skin disease, and dentists check condition of teeth by the fluorescent effect produced. Besides these applications "black light" is used extensively in crime detection, analyzation of mineral ores, bleaching of dyes and pigments, and in many other ways.

The radiations have a very short wave length, 1,000 to 4,000 angstroms, to be exact. This range lies between visual light on the one hand and Roentgen rays on the other. The angstrom unit is equal to 255 millionths of an inch. Except for the wave length, these radiations are virtually the same as those which produce the light we see every day.

However wide the applications of the ultra-violet rays have been in the past, a new scientific technique has opened fields that promise to completely eclipse past methods. The new technique is the Rentschler-James process for sterilization by means of ultra-violet radiations. It has been developed by Dr. H. C. Rentschler, director of research for the Westinghouse Lamp Division, and his associate, Dr. Robert F. James, staff bacteriologist.

It was known that the ultra-violet radiations killed certain types of bacteria, but there was no knowledge as to exactly which rays were responsible for this action, or just how complete it was. These were the questions that Dr. Rentschler set out to solve.

Two things were needed before information about this action of ultra-violet rays could be effectively charted: (1) a meter to measure the amount of radiation, (2) a method of obtaining uniformly seeded plates, that is, cultures of approximately the same bacterial content. The first of these problems was overcome by Dr. Rentschler's photo cell for measuring ultra-violet radiations. It responds to approximately the same wave length band that is harmful to bacteria. Tantalium is the active element in this cell.

Dr. James and Dr. Rentschler working together solved the second problem. They sprayed a culture media into a large closed box, waited until the larger drops had settled out, and then simultaneously exposed several sterile plates for a short period to the atmosphere in the box. Thus they were able to obtain plates that had approximately the same bacterial content. This last technique alone saved years of effort in comparison to the usual methods for obtaining equally seeded plates.

With these two problems eliminated, the "99 per cent of genius" was undertaken, that is the hard work of making extensive tests with various types of lamps, glass and bacteria. After the radiation necessary to kill a definite percentage of bacteria was determined, the various wave lengths possible with ultra-violet light were tried out, and finally experiments were made with different mediums of transmitting the light.

It was found
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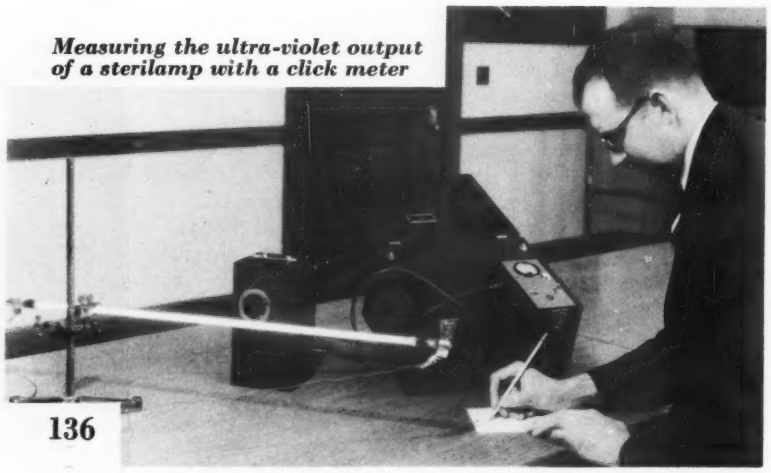
Measuring the ultra-violet output of a sterilamp with a click meter



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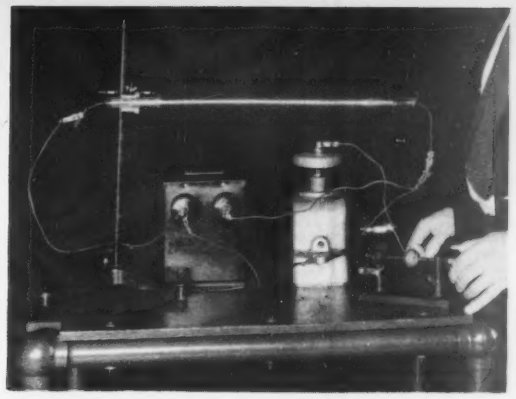
HT ● NEW BACTERIOLOGICAL PROTECTION



Argon tube showing change in character of discharge

was found that the greatest sterilization power lay in the 2,537 angstrom nd. That is to say that ultra-violet rays of wave length of 2,537 angstroms ne maximum killing power. This was the clue that led to the final design "sterilamp," as the Rentschler-James lamp has been named. It contains y vapor combined with other gases, the object being to provide the greatest onal powers in the 2,537 angstrom band. The glass was another problem, rdinary glass is opaque to ultra-violet rays of the necessary wave length. ised quartz possessed the desired high melting point but was experimentally onomically impractical. The answer to this problem was found in the ghouse laboratories where the necessary grade of glass was developed.

us, after five years of extensive and combined research, the "sterilamp" signed. So much for the scientific background of the subject. The lamp perimentally proven correct. There remained only a demonstration of its read commercial applications.

e new lamp gave promise of providing not only a quick, inexpensive, and e way to sterilize foods and eating utensils, such as no heat treatment or al could do, but it also offered a third dimension in sterilization, as the mp" could effectively kill bacteria in the air.

the baking industry ultra-violet treatment of the air and of goods reduces e wastes. It also makes possible the delivery of "fresh" goods two or three ter they are baked.

hospitals, "sterilamps" have proven themselves invaluable not only during ons but as a general sterilization utensil. Dr. Deryl K. Hart, surgeon-in- Duke Hospital, Durham, N. C., made extensive tests with this lamp. He hat ultra-violet rays destroyed practically all of the bacteria around the ve wound and instrument table. The post-operative temperature curves of ients were much lower and wounds appeared to heal faster. As a result of estigation, the sterilamp is now operating in the Mayo Clinic, New York l Center, and other well-known hospitals.

public places, such as drugstores, the sterilamps have, for the first time, ed the maximum sterilization of public utensils, as the law requires. Drink- ses exposed to the lamp were immediately sterilized and preserved in that n as a result of the action of the lamps on the bacteria of the air. The ave a 99.99 per cent sterilization.

ra-violet radiations for sterilization are just beginning to enter the field of litioning, which, moreover, appears to be limitless in scope. Not only will valuable to the manufacturers of commercial products, but by reducing the of bacteria in the air the potential and incidence to disease are reduced. an be seen that the field for this new sterilization technique is practically ed. The "sterilamp" will shortly become as equally common in the factory, nd store, as in the hospital.

Thin-window bactericidal lamp

All photographs courtesy Westinghou

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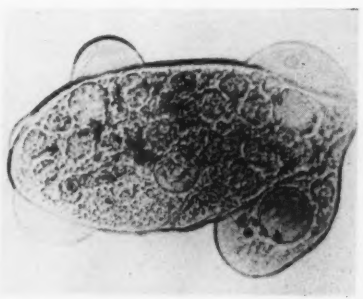

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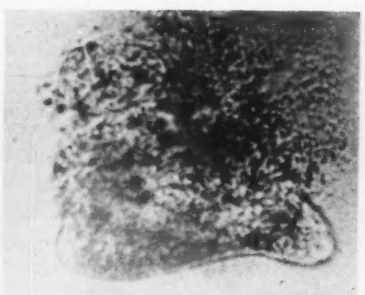
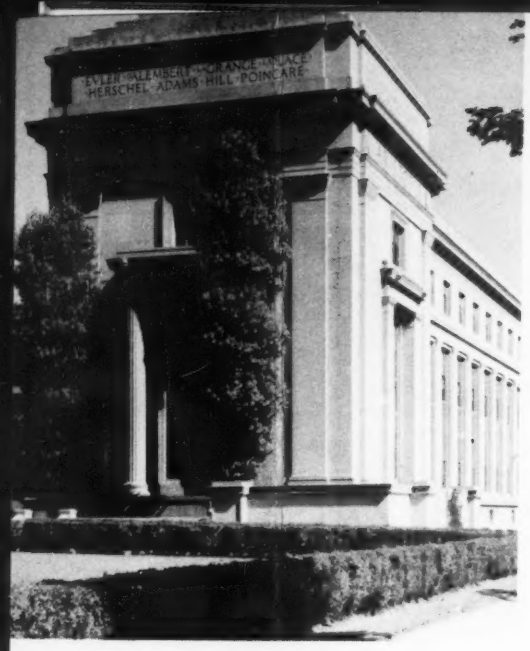


RISE AND FALL OF PARAMECIA

1. Normal paramecia
2. Paramecia showing the distension which occurs after thirty seconds of irradiation by ultra-violet light
3. The death throes of a paramecium which is dying from the effect of the ultra-violet radiation. Death occurs by a change in the osmotic tension of the cell wall which causes the organism to swell
4. The paramecium is dead from an internal explosion. Ultra-violet radiation has made this one-celled animal burst its skin. The contents of its body are disintegrating and mixing with the surrounding water



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EDITORIALS

FROM 17 TO 6

Recently President Compton dedicated to William Barton Rogers a beautiful new addition to Technology. This building, topped by a dome one hundred feet high, is certainly a fine memorial to so illustrious a gentleman. However, it was also built to fill the more necessary and practical needs of the architecture students. Half of this new wing is now occupied by our very welcome schoolmates who heretofore worked in the old Architecture Building of the "Tech on Boylston Street." It is an excellent new quarters that has been provided for them and the conveniences gained will soon erase the fond memories they still hold for the old Rogers Building.

However, on September 26, registration day brought quite a shock when only six full-time freshmen entered Course IV to take the advantage of all these excellent facilities provided for them. There was a slight increase in enrollment among the upper classes. If the Institute were fortunate enough to attract this many men each year in the next five years it would mean that there would be only 30 students of architecture occupying the four floors of this large wing by the time this entering class was ready to graduate. Your first reaction when you read this is why did the registration drop from seventeen last year to six this year. You will recall with little difficulty that the tuition has been raised to $600 a year, and although the Institute can boast of an increased freshman class it should not overlook the disastrous effects on Course IV registration. Perhaps you inquire why the architecture students should react in this way. There are many reasons.

First, the architecture students are obsessed with a greater enthusiasm for their course than most other engineering students and as a result we find more of them coming here to Technology with a definitely limited budget, since they are more willing to make great sacrifices to get through their studies. To this is added the burden of another year. For theirs is a five year course before they can enter their field of work which today offers discouragingly few opportunities. So this increased tuition means $500 added to their total schooling budget and $600 more than the regular four-year engineers pay. And then they have no use for the elaborate facilities that Technology can offer such as the electrical engineering, hydraulics, spectroscopy, and chemical laboratories. Their activity is largely confined to a drawing table representing an Institute investment of perhaps $40. We engineering students in other fields can breathe with relief after we have managed to pay our terms tuition plus a small laboratory fee, but the pocketbooks of our brother architects must still absorb added expenses such as drawing boards, expensive drawing instruments, triangles, T squares, pens, ink, pencils, water colors and drawing papers. The freshman year these expenses easily exceed $100, and the following years such investments total near $65. So you see the added financial burden placed on these men.

Now even if a prospective student could afford to attend Technology, he would be justified in going elsewhere because Technology cannot boast of giving more for his money than any other school. There are many other good architectural schools almost if not equally as good with tuition rates half and two-thirds the cost of our own school. Several such schools are Cornell

Princeton, Penn, Columbia, Harvard and Yale. It is still possible to attract students to our other engineering studies because the superiority of these other courses can justify the cost differential, but Course IV has no great man like Groppius, now at Harvard, to attract students.

Since our architectural course is so evenly matched by other schools, it seems only natural and necessary for the Institute to drop the tuition rate for architecture students to the same level as these other schools in order to avoid the slow extinction of this fine course. It is extremely important that the Institute give this problem serious consideration. Would it not be possible and more fair to assess the architects the same for getting their Bachelor's degree in five years as we are for our four years work towards a similar degree? We know that it is not their policy to enforce limitations on education by surrounding Technology with a financial barrier just so more income may be gotten and expended for costly research. It would certainly be a noble gesture on the part of the Institute to lower the tuition in the Architecture School and thus open once again the doors of educational opportunity for this deserving group of students.

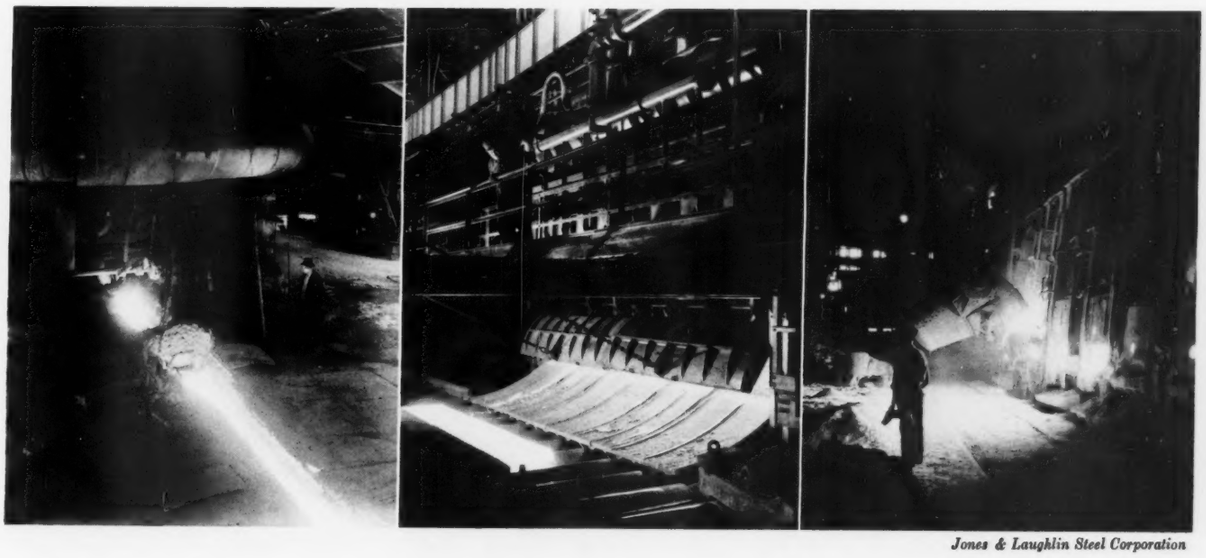
EUROPE ON A SHOESTRING

The announcement on the T. C. A. bulletin board that requests the names of all students interested in taking a round-trip trans-Atlantic crossing for $80 is an announcement which you may never see again. Here is a prospect of spending a summer in Europe — an undertaking you might ordinarily never consider, because of the heretofore insurmountable expense of ocean liner passenger fares. Third-class rates on passenger liners average about $200 a round trip. And it is this initial expense that discourages most trips abroad.

In the projected plan for this unbelievable America-Europe passenger service, an English transport ship ordinarily out of service during the summer months will be used. The ship will be converted into a single-class passenger ship with girls' and boys' quarters in separate parts of the ship under competent leaders. A dormitory system will be devised using berths or hammocks for sleeping. In order that the crossing fare may be kept close to $80 it will not be possible to give the elaborate service which is so responsible for present high rates. The meals will be simple and served with the assistance of passengers. The ship, chartered from responsible, reliable owners, will conform to the highest safety standards. Each passenger will be permitted to carry ten cubic feet of baggage free. The American Youth Line, the sponsor, hopes to schedule sailings every three weeks, depending on the number and desires of the applicants.

Such a trip will make for an ideal crossing, since the informality and friendliness will reach the maximum so often desired by student groups who disdain the formality so often found on regular passenger crossings. You will be meeting persons of your own age from all over the United States and exchanging ideas continuously during the eight day crossing. Further benefit will be derived from language classes and travelogues conducted during the crossing, thus preparing the students to enjoy better the time spent in Europe.

The benefits of travel have been much discussed and emphasized, but one important element often overlooked should be mentioned here. The opportunity to meet and live with the people of other countries makes for a better understanding of the social, political and economic problems which are today the source of much debate. The international difficulties facing the world at present are in many cases the result of misunderstandings provoked by not knowing the people, not appreciating their outlook on life and ways of thinking, and not realizing the problems peculiar to their race and country. If only it were possible that all had the opportunity of visiting the more important foreign countries, world peace would not be just an evasive idealistic dream. Unfortunately all cannot make such visits, so we must depend on annual migrations of tourists to bring about this understanding. The American Youth Line is taking the lead in increasing the number of travelers, especially in that college-age group which is most open-minded, most eager for education, most willing to understand people, and most helpful in correctly informing their friends in the United States — a country which least appreciates European difficulties, because it is so far removed and independent of their actions.



Jones & Laughlin Steel Corporation

Relaxing on the beach in Denmark

SEEING INDUSTRIAL EUROPE

Every year a group of Tech men make a summer trip to Europe, as the Thorne Loomis Industrial Tour. This tour is organized and conducted for the purpose of acquainting a party of engineering students with foreign industrial practice by visiting a great number and variety of representative European industries. The secondary and equally important purpose is to allow sufficient spare time to enjoy and absorb the cultural opportunities to which all are continually exposed. Another attractive element is the low cost, made possible by traveling in a specially designed bus, loaned to us by the Thorne Loomis Foundation. This bus is unusual because of its unique design. The duraluminum body carries twelve men and contains individual luggage compartments which run horizontally under the truck. The back of the truck, used for a table when four steel legs are screwed into place, can be removed to expose large compartments for carrying food, a gasoline stove, cooking and eating utensils, and first aid equipment. The canvas top unfolds to form a complete tent, extending five feet out from the sides of the truck. Spring beds are hung in place on the sides, while mattresses and blankets add to the comfort of sleep. During travel the beds and bedding are packed under the seats. By camping out at night and cooking our own meals, living costs are kept to a minimum. When in large cities, however, we stay in hotels.

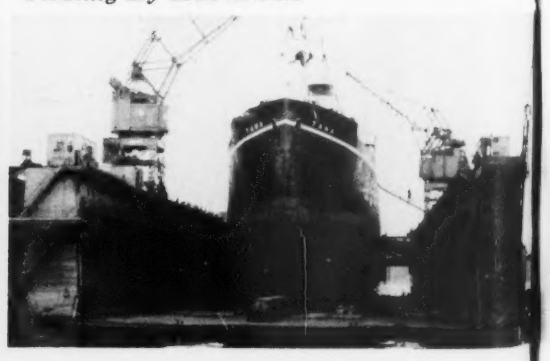
This summer we left on June 3 aboard the *S. S. Statendam*. In the succeeding twelve weeks the tour found itself in England, Scotland, Norway, Sweden, Denmark, Germany, Switzerland, France, Belgium and Holland. In this period of time we were able to make twenty-five plant visits and see how European industrial procedure differed from, surpassed, and fell short of American industry. The group was usually split into two parts and thoroughly conducted through the factories by competent English-speaking men — either plant managers, factory engineers or executives. The thoroughness with which we were shown the operations and the willingness of our guides to answer all the questions we could possibly devise gave us a wonderful understanding of foreign industry.

It may be interesting if I point out a few of the many visits we enjoyed. In Stockholm we were very fortunate in being able to visit several of the enormous co-operative industries, two of which were: the Luma Electric Light Company and a Co-operative Flour Company. After being shown the former plant, including the complex machines for putting filaments into light bulbs and sealing the bulbs under vacuum, we had dinner with a group of Stockholm business men and economists. After dinner one of the men explained very clearly the wonderful co-operative system that knits Swedish industry into a powerful depression-proof institution, and gave us all a copy of a recent paper written by him which explained the system in further detail. A week later we spent a morning at the world-famous Georg Jenson silversmith plant, which gave us the opportunity of seeing the skillful making of the highest quality hand-made silver articles that it is possible to buy. That afternoon, we had the pleasure of being personally conducted through the Heering Cherry Brandy Works by Mr. Peter Heering himself. Another highlight of our industrial visitations was a day spent at the enormous Siemens Electric Co. outside of Berlin. This company, similar to our General Electric Co., employs one hundred and twenty-five thousand persons and has built a city, Siemens Stadt, to house them. The intricacies and details of administration and the usual Prussian eye for organization is remarkable. About the middle of August we pulled into Cologne, and after seeing the beautiful city and its inimitable cathedral we enjoyed a day at the Fortuna

Dynamite factory in Norway

Making ready for camp

Floating dry dock in Oslo



brown coal mine. This brown coal is lignite dug out of enormous pits which are miles across and hundreds of feet deep. Gigantic machines scrape the coal from the sides of the pit and load it into small cars which carry the brown coal to the plant where it is processed and pressed into briquettes. At the same plant electricity is made at the rate of ninety thousand KVA per hour for use in the industrial Rhineland.

This discussion can give only an inadequate insight into our activities. Some other outstanding visits were the Val-St. Lambert glass factory in Belgium; the sistership of the *Hindenburg* under construction at Friedrichshafen; the *Queen Elizabeth* on the ways of the John Brown Ship Building Company on the Clyde; Deutsches Engineering and Scientific Museum in Munich; Glasgow Empire Exhibition; dinner in Berlin with the V. D. I., Mechanical Engineering Society of Germany; several receptions at the homes of American consuls; and Perriet-Jouet Champagne cellars.

Despite the technical motive behind much of our travel we managed to absorb our fair proportion of European culture, and I believe we became better acquainted with the European people since we lived closer to them, buying food in their markets and camping in their back yards, thereby escaping the unfortunate classification of American tourists. The benefits gained from the trip are both obvious and intrinsic. I believe we all returned with a clearer understanding of the complex characteristics of foreign industries; a better appreciation of labor conditions, wage scales, and living standards; an observation of organization details and management procedures; and a general broadening gained from long free conversations with the men of industry.

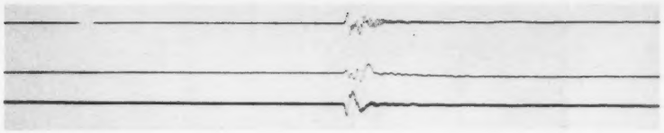
JACK H. SCHAUM, '40

SOUNDING THE EARTH'S CRUST

During the recent summer, we began seismic field work for the purpose of studying the geologic structure of the earth from the surface to a depth of approximately 15 miles. It is commonly known that the data furnished by earthquake records reveal much concerning the major features of the earth's interior. For a more detailed study of a thin part of the surface layer, however, it is desirable to have an earthquake at the surface, at a known point on the surface, and to have it occur when convenient. It is asking too much to expect this to happen naturally, of course, but the tremor caused by a large quarry blast has the desired qualities and makes a very acceptable substitute.

The data for our investigation were obtained by recording at a distance of many miles the tremor produced in the earth by the explosion of a quarry blast. We accomplished this by using eight portable seismographs, spaced at approximately equal intervals along a line terminating at the quarry. This line is first chosen by referring to maps, and the approximate positions for the seismographs are selected. It is then the task of a foundation party to go into the field to find geologically suitable sites in friendly territory and to construct simple foundations there upon which the seismographs will later rest. This means that a level outcrop of bed rock, free from local disturbing vibrations and preferably not far from a road, must be found within a few miles of the point previously chosen on the map.

It is necessary to know the distance between each seismograph and the quarry, and the time required for the elastic wave to travel this distance. We obtained the first of these by consulting maps of the United States Coast and Geodetic Survey, supplementing this information with the locations of their triangulation stations, the positions of which are known to a high degree of accuracy. The travel time is easily found, since the time of arrival of the wave is indicated directly on the seismogram, and the instant of explosion is known from records made at the quarry.



SEISMOGRAM
FROM STRONG MOTION RECORDER (2,000 feet)

The top and bottom traces represent the motion of two pendulums swinging at right angles in a horizontal plane. The center trace is due to the motion of the vertical component pendulum. Travel time, about 0.08 seconds. Transverse lines are second marks, 50th and 2d being omitted

Radio station W1XAL, in Boston, aided us most generously in transmitting time signals for us, which served as a link connecting all the parties involved during the five minutes of actual recording. In addition, a continuous time signal service at one second intervals was transmitted from Ottawa, Canada, by the Dominion Observatory, and these signals were also available, although at weaker strength, for aid in synchronizing the records at the various stations. The time signals, with suitable identification of certain seconds, were received by radio and automatically recorded on the vibration record of each unit. They served as the master control of all operations. Accordingly, we made out a schedule of events for each different group, indicating to the nearest second the time certain operations were to be performed. Thus the firing party at the quarry exploded the 15 tons of dynamite at a prearranged time, and the eight field parties put their respective seismographs into operation at the proper moment. We also recorded these time signals at Massachusetts Institute of Technology and compared them with those transmitted from the Naval Observatory at Arlington. In this way the absolute time of the explosion was determined, and the records from permanent seismograph installations, such as those at Harvard, Weston, and Williamstown, could then be used.

The sensitivity of our instruments varied. The strong motion recorder placed near the blast (2,000 feet) had a magnification of 30 times, and the most distant one (about 100 miles) had a magnification of 25,000 times, dealing with earth movements of about one one-hundredth of an inch and ten millionths of an inch respectively. The weight of each complete portable seismograph with its associated equipment was in the neighborhood of 200 pounds, which meant that a ton of geophysical equipment was moved from the laboratory into the field and back again each time a quarry blast was recorded.

Investigators in this country and in Europe, using data from local earthquakes as well as data from quarry blasts, have obtained evidence that the earth's crust has a layered structure. The continents seem to represent an additional layer, of granitic rock, which is absent in the ocean basins. The thickness of this topmost layer of granite varies from place to place; in general it seems to be between 10 and 15 miles on the

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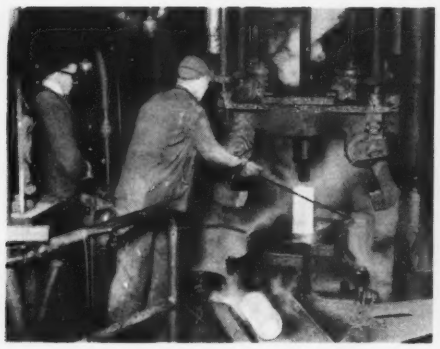

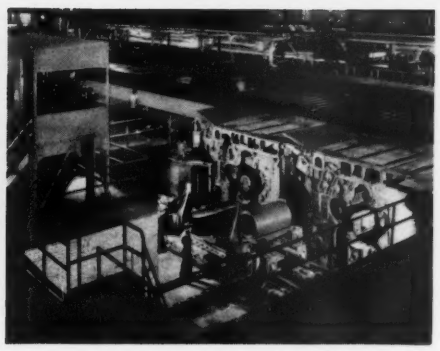

All photographs courtesy Jones & Laughlin Steel Corporation

TIME AND MOTION STUDY

(*Continued from page 132*)

for holding something while working on it with the other, are frequent violations of good motion practice. These violations may be filmed and shown to the worker in educating him to see his own faults and making him two-hand-minded. In many cases the development of jigs and fixtures for holding the work securely effectively releases both hands for productive effort.

The well-designed workplace, technically referred to as the circular workplace, is laid out with full consideration for the most effective use of the workers' motions and the elimination of reaching, lifting, and handling insofar as possible, particularly of heavy or fatiguing parts. The use of drop delivery chutes and conveyors for delivering the material or parts in the best possible position for the worker, and drop discharge chutes for carrying the finished parts away, invariably reduces both time and fatigue. The careful pre-positioning of tools and materials not only saves time in getting them for the next work cycle, but also stimulates better habits of housekeeping among the employees and more respect for their tools. It also materially reduces the learning time of beginners by standardizing the motion path.

Case studies and illustrative material for carrying on a program in Work Simplification usually may be found in abundance within any plant. When every individual in the organization has been taught to think of jobs in terms of elements of motion, and has also developed a questioning attitude toward methods, many by-products of the Work Simplification program will be evidenced. These improvements usually take the form of safer practices, better housekeeping, greater pride of service, increased knowledge of the necessary skill and purpose of the process, and invariably increased personal efficiency among the supervisory group.

The use of motion pictures has been found particularly helpful in illustrating the various laws of motion and principles of motion economy. Actual factory operations are filmed showing the original method of processing before any change is made. A later film is made of the improved method, visually recording the exact savings in effort and time over the original method, and illustrating more forcibly than by word the principles of motion economy which are involved. Films of such operations have proven invaluable in convincing an employee of the actual existence of waste in his particular method, thus reducing the problem to an objective and visual basis, rather than attempting to settle it on a basis of personal opinion.

The value and importance of motion study to the function of employee training cannot be overstated. Motion study has served to provide the plant instructor with a most useful and long-needed tool for establishing standard factory practice as well as the analysis of operator performance. In this connection still further use is made of motion pictures in training the employee in the new method. After being used for this purpose, the film is then stored away for future reference, constituting a permanent and accurate record of the method which can be projected quickly and easily should any question or controversy arise regarding the exact motion path which has been established.

Although it must be frankly admitted that there is nothing new or unique about the idea of scientific job analysis applied to methods improvement, nevertheless it is becoming increasingly evident that a new concept and a new approach to the subject have been developing in recent years. For many years those individuals actively engaged in this field of work have been thoroughly aware of the human relations problem involved in working out a program with the foreman, the staff, and particularly the individual employee. Today it is clearly evident that this human relations factor cannot be too strongly emphasized and that it assumes a major significance in a program of Work Simplification, while the use of specific techniques is relatively of secondary importance. As many analysts can testify, finding the "One Best Way" may be a reasonably simple problem, but to establish it as standard factory practice, to train the employees in it, and to ensure their continued use of it, invariably involves problems of conflicting ideas, personality, and human relations.

It is extremely important that a proper concept and understanding of *what* Work Simplification really is be clearly and firmly established in the minds of management, the supervisory organization, and employees alike. Work Simplification may thus be clearly distinguished in the workers' minds from the so-called "speed-up" or "stretchout," which is also designed to increase employee productivity, but which does so only at the expense of the worker who has to work harder or faster to attain the same level of earnings as before.

Unfortunately this similarity of objectives between Work Simplification and the so-called speed-up has confused some workers into believing that the methods of accomplishment are also identical. In the absence of proper information they have reasoned that any effort to increase employee productivity must be, *per se*, inimical to the best interests of labor. Unfortunately in some cases the resentment arising out of bitter experiences with the speed-up has been directed against Work

(*Continued on page 143*)

(*Continued from page 142*)

Simplification. Yet Work Simplification has been conceded by many enlightened labor leaders to be a wholly ethical and fair method of increasing employee productivity by eliminating the unnecessary and wasteful expenditure of human energy and skill. In order to correct or preclude misunderstandings on this point, the more progressive managements have met this issue with carefully planned programs of employee education which have resulted in quieting their workers' fears.

It has been demonstrated frequently that the effectiveness of a program in Work Simplification is directly proportional to the degree of co-operation and mutual effort of the three groups enumerated: management, supervisory organization, and the employee. The first step in enlisting such co-operation and mutual effort is taken only when there is complete knowledge and common understanding as to *what* it is all about, *why* it is necessary or desirable, and *how* it is going to be accomplished, particularly in regard to what effect it is going to have on the work and the worker.

When Work Simplification is properly explained, employees are quick to recognize and admit that it is only with the elimination of all forms of waste, and the most effective utilization of human energy, that the highest possible remuneration to them can be justified, and by the same token, the greatest degree of job security obtained. On such a basis Work Simplification is translated from a one-man or one-group activity into a common concern and interest of the entire personnel, from the president down to the office boy and the janitor. As such, it may well provide a common meeting ground which will serve to promote sound employee relations and industrial harmony. However, it must be emphasized that these things do not "just happen"—they must be planned and worked for.

In contrast to this philosophy is the fact that until quite recently methods-improvement work in the plant was generally treated, if at all, as a tool of the specialist, the motion and time study man, or the so-called methods engineer. These were staff men trained to apply the techniques of motion analysis to plant operations. As specialists or "experts" they usually worked out their problems alone, giving little or no consideration to either the operator or the foreman. Naturally, these specialists not only limited their achievements to the extent of their own personal capacities, but also invariably established a feeling of opposition, if not open resentment, on the part of both the worker and the foreman. The foreman, with the "it can't be done" attitude, typified the usual reaction to such treatment and indicated the necessity for a better approach.

It therefore became obvious that the best way of enlisting co-operation and capitalizing on the skill and experience of both the worker and the foreman was to make them a definite part of the program. Such a course of action quite naturally involves a program of education, requiring more time and patience, but paying infinitely greater dividends in employee morale and co-operation. On such a basis the program virtually multiplies the efforts of the motion study analyst by developing a degree of *motion-mindedness* throughout the entire organization, producing better ideas and more harmonious co-operation and understanding among employees, supervision and staff.

While it is true that the greatest progress in promoting Work Simplification has taken place in the industrial area, particularly in mass production and highly repetitive types of manufacturing operations, nevertheless one should not carry away the idea that the application is limited to this field. It has been stated that probably more energy is being wasted in the ordinary kitchen than in all other places put together. Hence, the development of the new field of Home Management. Many opportunities for the application of Work Simplification have been discovered in routine office work, banking and cashiering, in hospitals, laundries, and even in agricultural activities.

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(*Continued on page 144*)

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TIME AND MOTION STUDY

(*Continued from page 143*)

motion study as an essential management tool by including such courses in their industrial engineering and management curricula. The various management professional organizations have extended recognition by scheduling talks and discussions devoted to this subject. These courses and meetings, together with the publication of numerous articles and textbooks, have all tended to stimulate a widespread interest and served to popularize this field of work.

Today industry is confronted with constantly increasing competition and sharper competitive practices, ever-rising material and labor costs, newer forms of taxation, an annually increasing Social Security burden, and an unprecedented growth of restrictive legislation in the production and distribution of its products, resulting in constantly increasing administrative costs. These conditions are forcing industry to become more concerned with the most effective utilization of the time, skill and energy of its entire employee group. Cost reduction secured by such means as rate cutting, chiseling, and the speed-up is censured by public opinion, management and labor alike. On the other hand cost reduction secured by means of general wage cuts is generally recognized as an open invitation to labor agitation and possibly costly strike situations. In contrast to these methods Work Simplification has much to offer industry as a humane, logical and thoroughly constructive program for increasing employee effectiveness and productivity and for reducing manufacturing costs.

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CROWDING THE JERRY-BUILDER

(*Continued from page 135*)

would be likely to balance. Where the ruling circumstances, such as differences in needed accommodation and in the aspect and nature of the site, permit a sufficient number of dwellings to be erected at one time in one place, no doubt standardization may be carried somewhat further in the direction of floor, roof and partition sections, but here also increased difficulty and expense in transport and in handling the larger units, not in a factory under a crane but on the bare site open to the wind and the weather, must reduce any possible savings to a very small proportion. It is the building of the shell and its foundations that mainly appears to lengthen the period of erection, but this does not add so much to the time or cost as is often supposed. Indeed even if 50 per cent of the cost of the shell could be saved by prefabrication, the percentage on the total cost would seldom exceed 15 per cent; and, as we have seen, if this were secured by reducing the reputed life of the building the reduction in rent would be negligible. By all means let experiments be made. No doubt improvements can and will be found by diligent research. It is well, however, to realize the conditions and the limitations which the nature of a dwelling impose. America is faced with a serious housing problem; to solve it many dwellings must be erected, and let for some time at rents which will not meet the outgoings on present costs of building. My suggestion is that there may be ways of reducing those costs other than that of prefabrication; ways which are available and offer at least a more immediate prospect of results. Some of them may even be found to have been important in producing results in the much quoted motor industry. Among the means of securing economy I should place first a settled long date program to be adopted in each locality, the realization of which will be carried on continuously. This would allow the second means, *i.e.*, of good and appropriate organization of the work, to be fully adopted. With such a fixed program materials can be bought in bulk on favorable terms and delivery arranged in a constant stream where and when required. The work on the site can be laid out in advance, the stages following on in the best order and in regular time sequence. Extra house shells can be constructed in the finer periods of the year, and extra indoor work planned for the wet and wintry periods. Indeed the methods and many of the economies of mass production can be adapted to the particular circumstances of building dwellings, without attempting to follow the misleading analogy of a portable motor car. In such a continuous process of production, experience will soon show what further elements of standardization can be introduced with advantage; and what types of design and construction can be erected at the most moderate labor cost in proportion to the results secured. On flat sites, for example, the fact that the largest space is enclosed by the least length of wall when approaching square in form may be remembered; while on sloping sites the shallow house having frontage longer than the depth, and set parallel to the contours, may easily save in foundations and digging more than enough to pay for the few extra feet of containing wall. The temptation to cut cost by skimping the size of a dwelling or its rooms, becomes greatly reduced in attractiveness when the mass of constant costs, which are not affected by such reduction, is realized. Experience shows that in a cottage costing two dollars per square foot of total floor area, any expansion or reduction of the area without

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CROWDING THE JERRY-BUILDER

(*Continued from page 144*)

altering the plan will affect the cost of the building not by two dollars per foot, but only by about 75 cents, so great is the importance of the constants. In England the cost per square foot of total floor area measured within the containing walls was found to give the most convenient and practically useful basis for comparing and checking the costs of large numbers of dwellings. The average size of dwelling first aimed at was about 800 square feet, which would be provided in a square building having two floors measuring within the main walls 20 x 20 feet. At two dollars per square foot such a house costs $1,600. Present costs, without the site, of a cottage building containing a living room, kitchen, bathroom and three bedrooms average about $2.25 per square foot, being higher than a while ago. This measure of cost is kept and reported in reference to all housing schemes or contracts; and the average cost is published at frequent intervals by the central government as a guide and measuring stick. The areas and costs just given refer to single family dwellings which have constituted over nine-tenths of the million dwellings so far erected by English municipalities. The same methods of assessing and comparing costs are equally applicable to apartment dwellings. In England the cost per square foot of these would be nearer three dollars as compared with two dollars for single family dwellings. Another method of price control proved very valuable in the period of excessive prices after the war. This was the record on every housing scheme and the regular reporting to the central government of the number of hours of labor occupied in the erection of each batch of houses completed. In the first schemes this figure, which included all the labor on the site, reached as much as 4,000 hours per dwelling; but after a year or two the average fell to 2,000 hours and below. How much of this was due to improved aptitude or inclination to work on the part of returned war-weary men, how much to improved organization and more steadily continued working, and how much to improved planning, no one can say, but they all helped, and the total effect was sufficiently startling to suggest that similar methods of comparison and control might be worth adopting in the United States of America. The custom of assessing costs at so much per room is liable to be very misleading because of the constants already mentioned, most of which must be incurred for the one or two room dwelling as much as for the four or five room one. When wishing to describe a dwelling by rooms, mention of the number of bedrooms as a guide to accommodation and cost, taking the living space, bath and other constants for granted, is free from the suggestion that the rooms entail an equal cost. In a four room house, if the kitchen and bath are not counted as rooms, and the total cost is $4,000, the actual cost of the rooms instead of being anywhere near equal would probably be nearer I room $1,750; II room $1,000; III room $750; IV room $500; and the rents of the different sizes of dwelling should vary more nearly with such relative costs than with the number of rooms.

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STARS TO CYCLOPS

(*Continued from page 130*)

scope about two axes: rotation of the mounting carrying the tube about the polar axis from east to west, called the right ascension, and the rotation of the tube on its declination axis from north to south. After the setting on the star is completed, the instrument follows the star; that is, it continues to rotate in right ascension about its polar axis, being driven by a sidereal clock.

The complete optical system comprises eight mirrors which are carried entirely on the telescope tube and mounting. The 200-inch mirror, supported on 36 compensating mechanisms, is located within the bottom ring of the telescope tube. The reflected image is formed at the prime focus ($f/3.3$) in the observer's house, which house is supported on knife-edges — thin edgewise strips of steel — from the cage at the upper end of the tube. This is best seen by referring to figure, point A. Underneath the observer's house and only narrowly separated from it is another chamber mounted on the cage or upper, circular part of the square tube, and containing three auxiliary mirrors with their moving mechanisms, shown as point B. These mirrors are used, one at a time, for forming images at (1) the Cassegrain focus, $f/16$ (point G), located beneath the lower end of the tube, and (2) at the coude focus, $f/30$, located in a constant temperature room at the south end of the dome (point H); either two or four auxiliary mirrors are used for the work at the coude focus. (3) Another three-mirror combination forms an image inside the tubular girders of the mounting at the coude-Cassegrain focus $f/16$ (point I). The light path for various mirror combinations used is indicated on the sketch. The prime focus is intended to be used generally for direct photography, while the work at the coude and the Cassegrain foci will be mainly with spectrographs. The Newtonian diagonal will have no part in the use of this telescope. It is intended to do away with this reflection and to use the prime focus directly from the big mirror.

The entire tube, over 55 feet long and 22 feet wide, weighing approximately 250,000 pounds, is suspended on the declination axis trunnions from the mounting which forms the polar axis of the telescope. The bearings of the telescope are of the forced-feed oil-pad type. At the north end, the horseshoe is supported on two equalized pairs of oil pads spaced at an angle of 60 degrees. The south bearing is formed by an 84-inch diameter spherical cup resting on three self-aligning pads. When a continuous flow of oil, under high pressure, is delivered through orifices to the surface of the pads, an oil film is formed between the pads and the horseshoe or the spherical cup at the north and south ends, respectively, thus floating the 1,000,000 pound weight of the 200-inch telescope.

The yoke consists of two 10-foot 6-inch diameter tubular girders, spaced at 35-foot center distance, tied together at the south end by a crossbeam carrying the south bearing, and at the north end by a very stiff girder four feet wide, shaped as a horseshoe in order to permit the tube to be pointed as low as the North Pole of the heavens. The overall length of the yoke is 60 feet 6 inches and its total weight is approximately 600,000 pounds.

The mounting, or yoke, of the 200-inch telescope represents its polar axis. It is supported on bearings placed on two piers and points north and south at an angle of 33° 21′ with the horizon. This angle corresponds to the latitude of Palomar Mountain, and the polar axis is, therefore, parallel to the axis of rotation of the earth.

The tube is turned north and south in declination by an accurate 14-foot 3-inch diameter worm gear, shown in the frontispiece at the lower end of the polar axis. Two worm gears of the same size are carried on bearings at the south pedestal and drive the entire telescope east or west in right ascension through a torque tube. One of these gears is used for setting the telescope on the star at a relatively high speed of one-eighth of a revolution per minute, while the other gear is driven by a synchronous motor through a suitable worm reduction at a corrected sidereal rate of one revolution per day. By using a separate gear for driving the telescope at the higher setting speed, which imposes heavier loads and strain on the gear, excessive wear of the accurate right ascension gear is obviated.

There is a main control desk, located on the operating floor within the north pedestal, from which the setting of the telescope in position and actuating the mechanisms of the shutter, dome, and of the wind screen are performed.

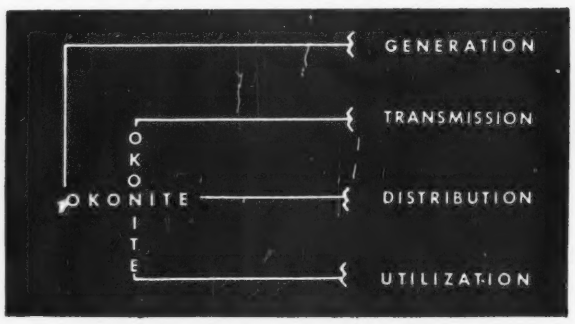
The 200-inch mirror, ground and now being polished to a concave spherical surface, later to be completed as a paraboloid, is made of boro-silicate glass having a low coefficient of thermal expansion. In order to obtain high reflectivity of light, the surface of the mirror will be aluminized.

The total thickness of the mirror is about 25 inches and, in order to reduce its total weight, the back of the mirror is of ribbed construction. It provides a rigid structure which is relatively light and permits rapid equalization of temperature in the entire body of the glass.

The mirror is attached to the welded steel cell by

(*Continued on page 147*)

THE 4-ø ELECTRICAL SYSTEM



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STARS TO CYCLOPS

(*Continued from page 146*)

means of 36 balancing mechanisms placed in ground pockets within the ribbed structure. In its turn, the cell is bolted to the bottom ring of the telescope tube.

Essential parts of the balancing mechanisms coming in contact with the glass are made of 38 per cent nickel steel alloy which has a coefficient of thermal expansion identical with that of the glass. The function of these mechanisms is to distribute the mirror load evenly among them and prevent redistribution of the individual loads on the supports at any position of the tube. The tendency of the mirror to distort, when rotated from one position to another, is thus eliminated.

In the center of the mirror is a 40½-inch diameter hole which permits the light, reflected from an auxiliary convex mirror at the top of the tube, to pass through the 200-inch disk and form an image at the Cassegrain focus (*f*/16).

When not in use, the 200-inch mirror is protected by a strong, mechanically operated cover. This cover is thermally insulated and, by means of overlapping auxiliary leaves on the under side of the main leaves, a modified iris diaphragm is formed. This permits "stopping down" the aperture of the 200-inch mirror, when desired, during some astronomical observations.

Directly underneath the observer's house is another six-foot diameter chamber containing the auxiliary Cassegrain and two coude mirrors. All these mirrors have to be out of the way of the light beam when work is carried on at the prime focus, and only one of them is used at a time for work at the Cassegrain or coude foci. Accurate positioning and locking mechanisms are therefore provided in the chamber, in order automatically to operate the mirrors with their counterbalances. A quick change-over for work at different focal points will thus be obtained on the 200-inch telescope. On smaller telescopes built previously, single mirrors are permanently attached to several cages; changing of the cages on the telescope tube naturally consumed considerable time.

The six-foot diameter observer's house at the prime focus contains the plate holder with its guiding eyepieces and Ross correcting lenses which permit sharp definition of the image over a field larger than ordinarily obtained. At last, astronomers will "ride the tube," an improvement for observation heretofore impossible. A special chair with a leveling device permits the observer to remain in a comfortable upright position independently of the position of the tube. The chamber will be fitted with telescope position indicators, and a telephone to permit the observer to communicate with his assistant at the main control desk 65 feet below him.

The access to the prime focus is obtained from a special platform running on an arc along the main arch of the dome. It maintains a constant clearance with the observer's house so that the observer may get in and out at any position of the tube.

There will remain probably two years of work in checking, assembling, and testing the main parts of the telescope itself, and in completing the grinding, polishing, and testing of the main and auxiliary mirrors.

BIOLOGICAL ENGINEERING

(*Continued from page 134*)

have produced this bone weakness in young rats and have determined the number of ergs of the particular wave lengths of monochromatic ultra-violet light which are efficient in curing this ailment. This information makes possible the design of therapeutic lamps which will be more useful and less dangerous than the type of mercury vapor lamp so commonly used for producing "synthetic" tan.

In the human body there are changing electrical conditions and the change of body voltage under controlled observed conditions may be of significant value in certain cases. It is now well known that currents in the brain are propagated at certain rates while a subject is at rest mentally, and that there is a different brain-wave rate for the same subject while he is working on a mental problem. The resistance of our internal tissues to the passage of a high frequency alternating current varies with different states of our health and well-being. The significance of measured impedance values of the tissues of living subjects can now be made with a minimum of inconvenience to the patient and studies are under way to determine if correlations can be established, for instance, between impedance value and fatigue. At every heart beat there is a definite voltage change between the top and bottom of the heart, which voltage effect is propagated throughout the body and can be picked up by external electrodes attached around, say, the arms and the legs. The recording of these voltage changes by the oscillograph has been the basis of one type of equipment for study-

(*Continued on page 148*)

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BIOLOGICAL ENGINEERING

(*Continued from page 147*)

ing the behavior of diseased hearts. These heart voltages can be picked up and made to reproduce with fidelity the frequency of the heart beat, and thus the electrocardiotachometer offers an objective measurement of frequency of the rate of the heart beat of a subject, displacing the older, less satisfactory method of counting the beats by taking the pulse. This device built originally to measure the heart rate of white rats, which is about five hundred beats per minute, was applied later to a human subject in an operation to enable the anaesthetist to follow the heart behavior of the patient, and is now used in classes to demonstrate how the heart varies in its rate with exercise, emotional strain and various other conditions.

A few examples of achievement in the fields comprising or contributing to biological engineering have been cited. These achievements have been made possible by co-operation between biologists, physicists, chemists, and engineers. Heretofore there has been no organized curriculum which would permit a man to start simultaneously in the field of biology and in the fields of physics and the allied sciences which contribute toward this work in the border-line zones. We now have available a formal course of study which embraces training in biology, chemistry, mathematics, physics and certain phases of electrical engineering.

Among the experimental techniques offered incident to this curriculum are those for recording measurement of temperature, pressure, humidity, air motion, the amplification of energies without distortion by mechanical or photronic electrical devices, radiation measurements, X-ray dosages, radio activity measurements; hydrogen ion concentration, oxidation-reduction potentials, vapor pressures, insulation thermodynamics, surface tension measurements, conductance and impedance in protoplasm, diffusion and osmotic effects across membranes, determination of molecular weights and of isoelectric points, colloidal phenomena, agglutination and antibody reactions, reflex time and tropisms. The training includes practice in technical skills required in design and construction of amplifier circuits, welding, hard and soft soldering, glass working, the use of vacuum pumps and the MacLeod gauge, the production and maintenance of uniform or varying temperatures with necessary precision, scientific photography and photometry, optical measurements, radiation measurements, spectroscopic analysis of biological materials, the use of supersonic devices, the research microscope, the ultra microscope, monochromators, quartz and lithium fluoride optical systems, the control of microbes and methods for their identification, biochemical techniques and those of food technology, economic biology and zymology.

Some years ago in the Institute, it appeared that the art of engineering and the science of chemistry could be combined in a curriculum of chemical engineering. The employment of the chemical engineer at that time was problematic. The sponsors of that new curriculum had faith that men properly trained in the proposed field would find their place in usefulness. The record of successful performance by our graduates in Course X speaks for itself. Biological engineering is at present in a similar situation to that which faced chemical engineering in its infancy. In each field there is a logical reason for combining various branches of sciences with engineering.

Biological engineering is not merely an invention of the thinking process, it is recognition of an existing situation and an existing need. The training offered is designed to meet that need and there is every expectation that the student who has met the requirements of this new curriculum will be so equipped technically that by combining his technical information with industry and ingenuity he may be expected to enjoy success in problems of research and of pure and applied biology as in medical schools, hospitals, foundations and biological institutes, universities, food industries, pharmaceutical manufacturing, industrial hygiene and in various government laboratories connected with agriculture, food, milk and standards. The field is a virgin one for the man of ability, imagination and courage. It offers a chance for creative work. There are no ruts in this field into which the biological engineer may stumble. His progress will depend upon his own power and initiative. No frontier of applied science has ever appeared to be more fertile ground from which to arrest a useful and interesting livelihood.

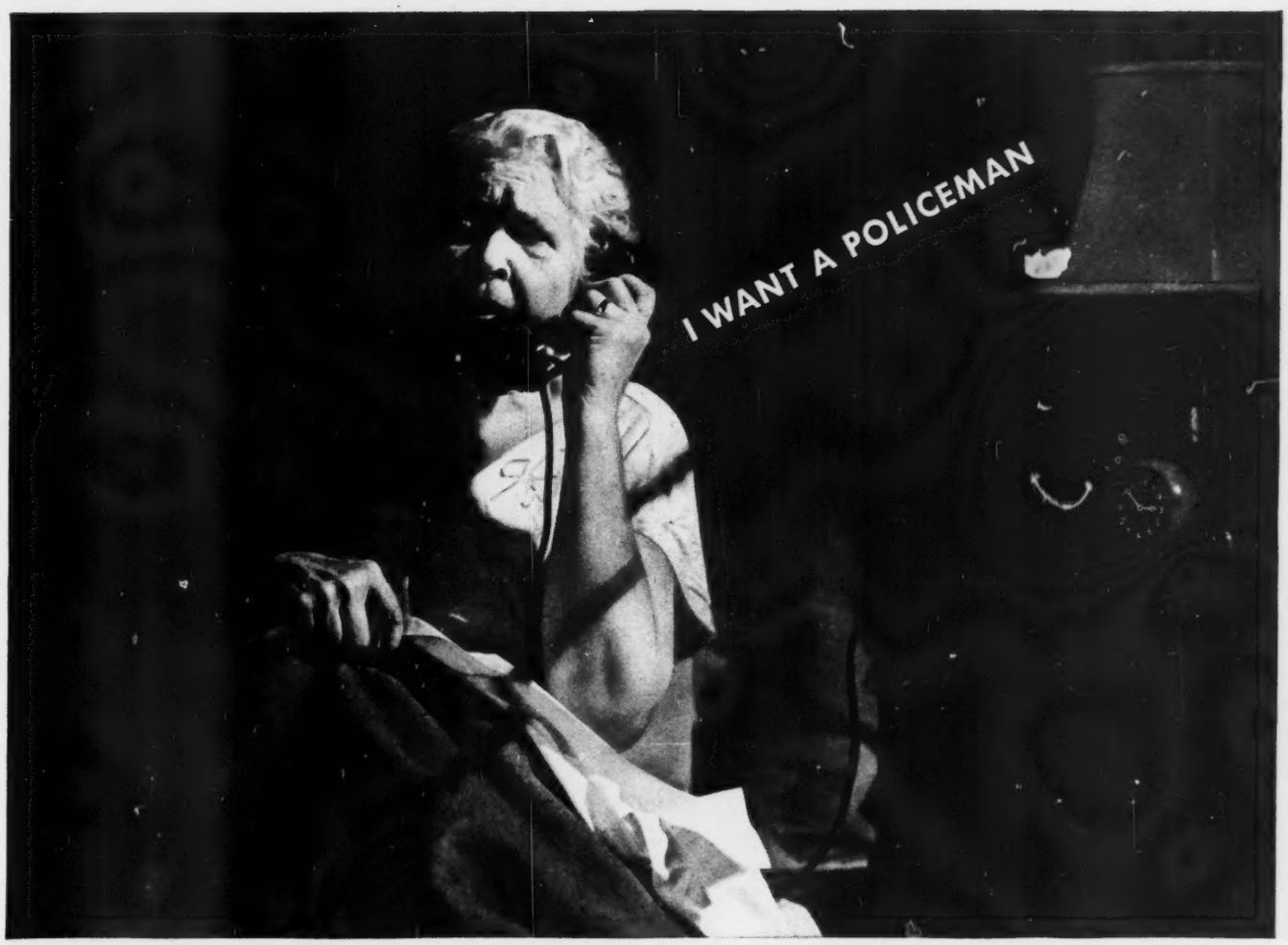
TECHNOLOGY

(*Continued from page 141*)

continents, but may vary considerably outside these figures. Below the granite layer, a layer of different composition, possibly 15 to 20 miles thick, appears to exist, at least in certain of the regions which have been studied. There has, however, been relatively little study of the structure of the crust from 10 to 40 or more miles deep; our knowledge about its nature is severely limited by lack of sufficient observational data. It is expected that the present investigations will shed some further light upon the New England structure at these depths, and at the same time give us a better understanding of the problem as a whole.

MELVIN L. JACKSON

Merck Research Laboratories



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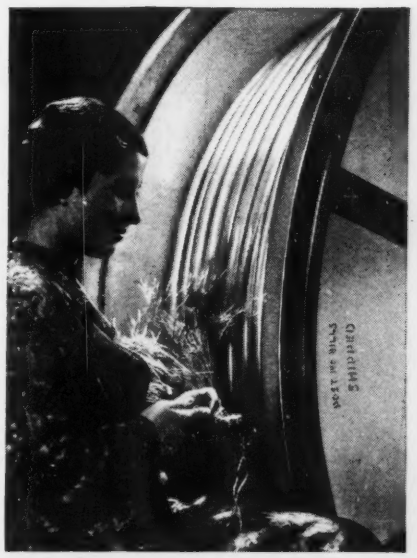

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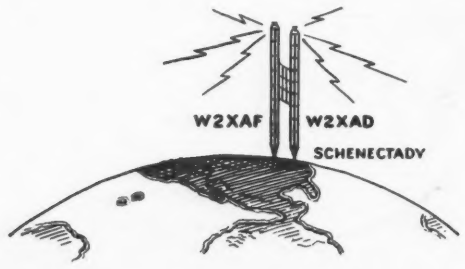
G-E Campus News

"MIDGET SUN"

FOR years Old Sol has had things pretty much his own way—causing sunburn, having sunspots, and wandering periodically north and south of the equator.

Now a young upstart about the size of a cigarette has been announced by General Electric. It is the new 1000-watt mercury lamp, which, even though many million times smaller than the sun, has one fifth the brilliancy of Old Sol's surface.

Source of the brilliant light is the lamp's highly concentrated arc—12 times more brilliant than the incandescent filament of a 1000-watt standard projection lamp. Laboratory tests show that the "upstart" will be of great value in searchlights, photoengraving, blueprinting, photoenlarging, and as an aid to medical science.



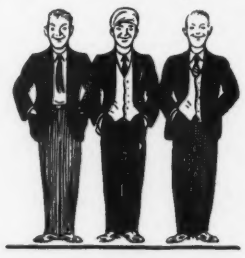
"AMERICA CALLING . . . ."

NEWS reports broadcast via short-wave radio from America told of troop movements in Spain; picked up in Barcelona, they aided forty refugees in escaping a war-torn area. An appeal for emergency contributions to a Red Cross flood-relief fund was heard in South America; Venezuelan oil-field workers answered with a donation.

Behind these events and others of front-page news were the two powerful short-wave stations of General Electric—W2XAD, and W2XAF, in Schenectady, New York. Since they first took the air, 12 years ago, the stations have figured in events of all kinds, have broadcast their programs to all parts of the earth. One of their weekly variety programs is an institution in South America. World Series baseball games have been heard in India and Arabia. The news reports of these stations are heard everywhere.

The steady stream of cards and letters from all over the world asking for information on the programs and congratulating the stations on their service is indicative of the good will that the stations are helping to promote.

The 150-hour-a-week operating schedule, headed by Eugene Darlington, Oregon State '28, ex-Test man, now features broadcasts of all types, on four different frequencies, in six languages—English, Spanish, Portuguese, French, Italian, German.



"FROM AMERICA, FROM INDIA, FROM ENGLAND . . ."

SCANNING the recent rolls of young men on Test with General Electric gives the impression of reading membership lists in an "International House" at some large university. For, intermingled with graduates of engineering schools all over the United States are, for example, Cariapa from Kashmir, in India; Bambery, from " 'way down under" in New Zealand; Gurewitsch, of Roumania; and Chia-Hsu Hou, of China.

But predominating in the picture are picked men from American colleges and universities. Selecting names at random from the various Tests inevitably shows student engineers from widely separated parts of the country working side by side. Miller of Arizona U. and Olsen of Brooklyn Tech. worked together on motor and generator tests. Schmid of Wisconsin ran turbine tests with Norris of Texas Tech. Testing induction motors were Loew of Washington and Owens of Union College.

General Electric's executives look upon this Test training as more than a graduate course in engineering—it is a carefully formulated plan of training young engineers for leadership in industry.

GENERAL ELECTRIC

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